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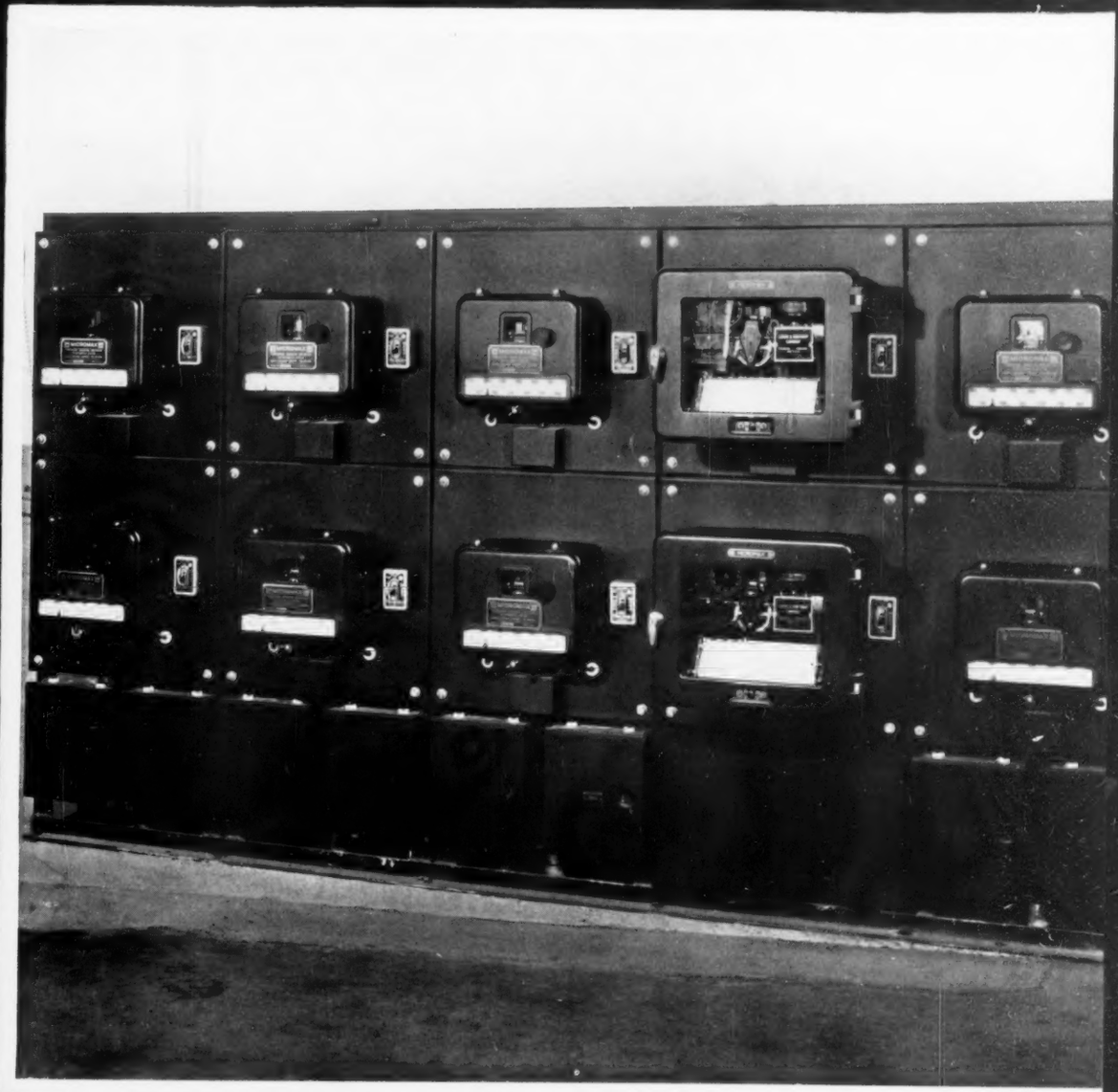
THE MAGAZINE OF

MEASUREMENT and CONTROL

INSTRUMENTS



INSTRUMENTATION OF GLASS TOUGHENING PROCESS
LIBBEY-OWENS-FORD PLANT, ROSSFORD, OHIO

MANOMETER ERRORS due to CAPILLARITY

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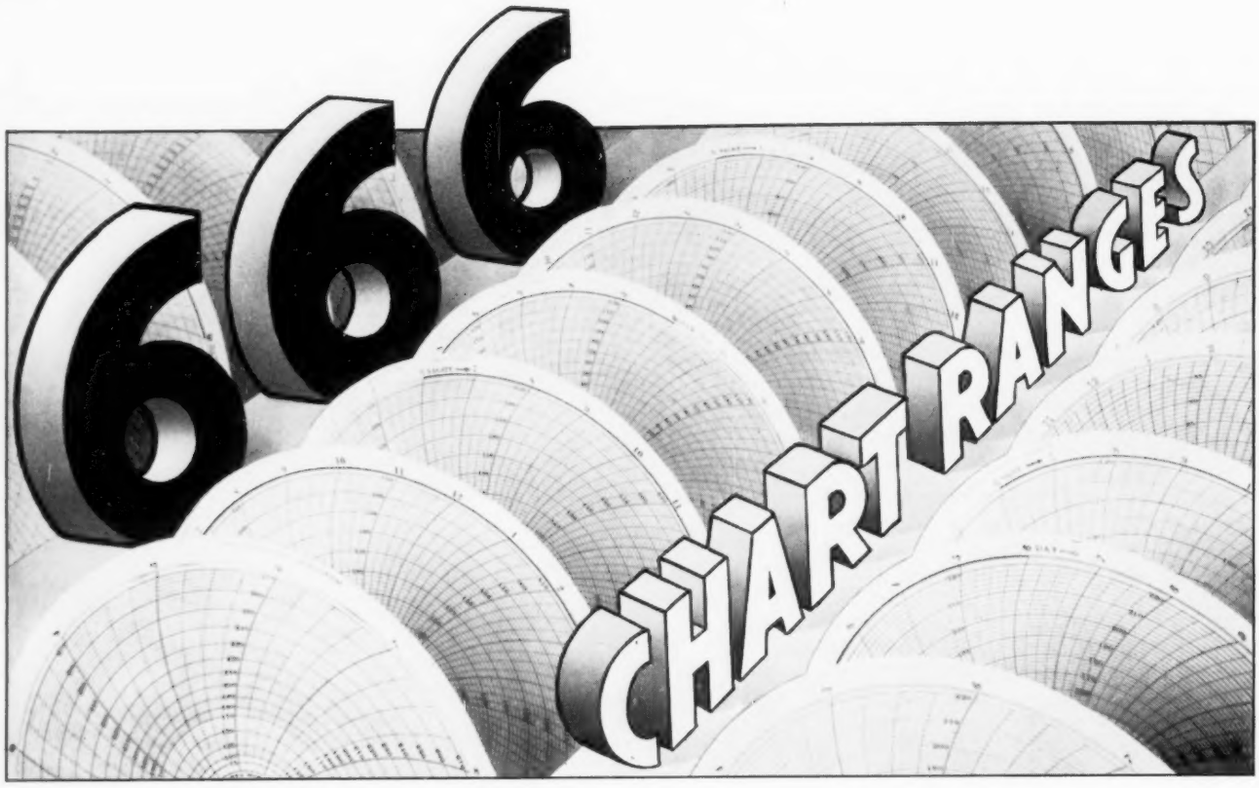
NUMBER 2



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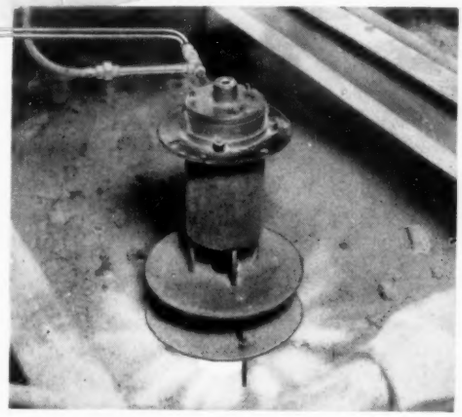
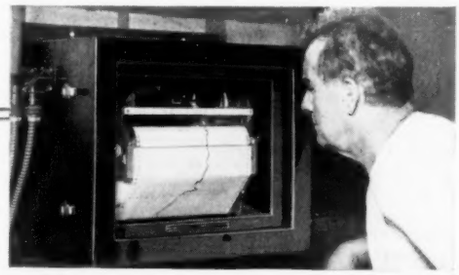
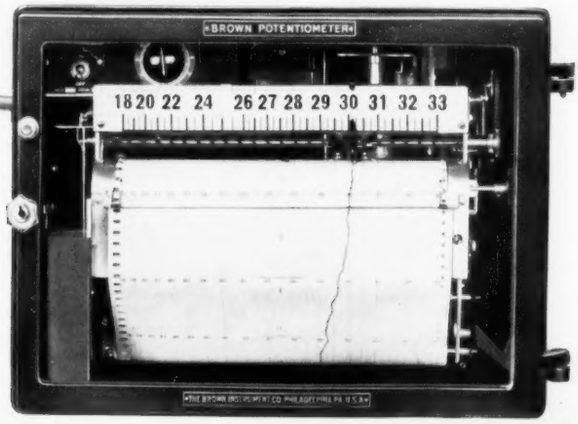


Brown Radiation Pyrometer Unit installed on Open Hearth Roof connected to Recorder for First Helper.





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BROWN POTENTIOMETER PYROMETER AND MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS

To Measure and Control is to Economize

INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

When the series on "*Instruments'* Readers at Work" was being planned, the expression "shirtsleeve sketches" often came up. Well, it turned out that our first subject (C. E. Fry, last month) does not usually work in his shirtsleeves and, since we aim to present a series of accurate sketches, we had him photographed as he always is to be seen at work: dressed up and well-groomed. Our second subject, S. A. Parlin, likes to roll up his sleeves on entering the Gage Department which he heads, so that this month we have a real "shirtsleeve sketch." But this doesn't mean that we intend to alternate regularly between dressy and shirtsleeve snapshots: we'll have you photographed as you are!

Several subscribers outside the radio industry have asked us, "Do you know what all the instruments in a broadcasting station are *for?*" If that question is on your mind you will be grateful for the explanation by Plant Manager E. H. Gager of Station KYW.

In using liquid-column instruments, capillarity effects should be taken into account. R. G. Folsom attacked this old question from a new angle—that of tube size—and reports his findings. For your convenience we have reproduced his diagrams in fairly large size.

A brief but useful note on measuring the slip of wound-rotor induction motors is contributed by H. R. Reed.

R. R. Batcher begins this month a description of time-base equipment for use with cathode-ray tubes.

Totalizing is the subject of this month's electrical-measurement article.

Remember our comment on the number of new instrument items coming in as we were closing last month's issue? Here they are!

The front-cover photograph shows the control board for the glass-toughening process at the Rossford (Ohio) plant of the Libbey-Owens-Ford Glass Co. All instruments are Leeds & Northrup "Micromax" potentiometers: eight indicating controllers and two recorders.

1936—AND YOU

MANY business and technical magazines published forecasts in their January issues. *Instruments* had usually done it in the past, but when our January issue was being planned, it was evident that a forecast of special interest to our subscribers would have been mostly guesswork: with Congress about to reconvene; with "main issues" undefined by Tweedledum and Tweedledee; with demagogues blaming unemployment on the very technology which creates industries and gives employment; with presidential nomination aspirants clamoring for both tax reduction *and* billions to farmers, veterans and other groups; with the rainbow-chasing organizations of "Mr. X and Dr. Y and Father Z" (see our December editorial) claiming millions of votes; with rumors of strange alliances linking some denouncers of the money-changers to some of the money-changers, the turn of the year was not the time which events prescribed for pausing to ponder and pontificate.

Now that the air is a little clearer it seems that (1) no sudden man-made disaster will cripple the industries from which you and we derive our earnings; (2) these industries will nevertheless have to bear an ever-increasing direct-taxation burden caused by an ever-growing number of dole-made unemployables and imposed by an ever-swelling governmental structure; (3) payrolls will be taxed increasingly to provide old-age security; (4) competition will grow fiercer in consumer-goods industries unequipped with "Institutes"; (5) the bonus and other forms of "pump-priming" will enormously broaden the distribution of purchasing power—until November as planned and perhaps longer—thus causing (6) a greater demand for goods and (7) a greater call on productive facilities, which, coupled with (8) a diminishing supply of skilled labor, and with factors 2, 3 and 4, will compel (9) a more determined search by management for labor-saving methods, inevitably resulting in (10) management's greater recognition of Instrumentation and instrumenticians.

Two years ago we reported on this page that the small number of changes on our subscribers' list (compared to those of other technical journals) showed that they constitute an exceptionally stable and secure *group* . . . but we said also that "the world doesn't owe a living to *each individual one* of us slide-rule users!" This still holds true. Don't depend on a Socialistic Santa Claus.

No. 2

STUART ALLAN PARLIN

Quality Engineer, The Bantam Ball Bearing Co., South Bend, Ind.

By M. F. BEHAR

PRIDE in his company and loyalty thereto characterize this month's subject to such an extent that when you ask him about *his* instrumentation work, he replies that Bantam produces 15 million needle rolls a week; that tolerances are to a "tenth" or better; that finished bearings range from 0.031″ to 60″ diam. in ball, roller and taper types for radial, thrust or combined loads; and that while maintaining the highest quality standards Bantam nevertheless produces more bearings per man-hour than any other bearing company in the world.

All of which may be the best answer to our question, for Mr. Parlin is the Quality Engineer of Bantam, and his intelligent selection, application and use of instruments contribute to his company's success. Certain it is that without modern Instrumentation no company could typify *both* highest quality and fastest production rate. Certain it is that the Bantam management knows this, for they recently invested relatively huge sums in a modernization program consisting largely of measurement and control devices.

Certain it is, too, that the new Gage Department laid out by Mr. Parlin is just about the last word in efficiency: in the combination of skilled personnel, fine equipment and optimal working conditions. Not only is the room air always maintained close to the 68°F. reference temperature of the linear Standards; not only is the illumination ample and glareless; but even the color scheme is a joy to behold: dark green steel cabinets, shelves, linoleum-topped benches and architectural trim; medium gray floor and machine frames; flat white walls and ceiling.

Focal attraction as one enters is the new Pratt and Whitney 80″ precision measuring machine which reads directly to 0.00001″. At the back of it a metal trough holds pin gages against the machine bed to make sure that all are at the same temperature. (Much neater than a messy oil bath!) Thermometers are located on this machine as well as on others throughout the room.

In addition to his work in the Gage Department, Mr. Parlin looks after some instruments used elsewhere, such as the precision "noise meter" used on small bearings. (See the partial lists on this page.)

Stuart Parlin missed being one of our charter subscribers because when *Instruments* was founded nine years ago he was only 22 years old and a marine machinist by trade. He soon rose to die and gage maker and designer, then to development engineer. Six years ago he subscribed. Today he considers *Instruments* "the most valuable magazine with regard to my bread-and-butter work." He frequently refers to it in the factory (as do the plant engineer and the heat-treating superintendent), and he studies it at home, where Mrs. Parlin also reads the articles which interest her. "She helps me with ideas" is his gallant tribute. . . . . Happy couple!

PRINCIPAL EQUIPMENT OF GAGE DEPARTMENT

Measuring Machine (see text).
Sine-bar Fixture for 12″ max. lengths, 0 to 180°, complementary angles, 10″ between buttons, 2″x18″ scraped base, clamping device for angle and height adjustment.
P & W "Electrolimit" Gage reading to 0.0001″.
125 O.D. Micrometers, 0-60″, which are built up and taken down as desired in large sizes.
62 Inside Micrometers, 0-60″.
78 Federal Indicators of various models, reading to 0.001″ and 0.0001″.
7 Large Verniers.
4 Sets of Johansson Gages.
1026 Angle Gages; 1481 Plug Gages; 224 Ring Gages; 799 Adjustable Pin Gages; 118 Adjustable Snap Gages.
Numerous Miscellaneous Length, Form, Radius, Squareness, Concentricity and other Special Gages.

OTHER INSPECTION AND TESTING EQUIPMENT

3 Rockwell Hardness testers (one taking work up to 3 ft. high)
3 Bulb Type Scleroscopes
2 Indicating Scleroscopes
1 Bausch & Lomb Microscope
1 Leitz Metallurgical Microscope & Equipment
1 Zeiss Microscope
1 Sound Level Indicating Equipment, complete with bench.
2 G-E Portable A-c. Testing Instruments
3 Westinghouse D-c. Ammeters

TEMPERATURE INSTRUMENTS IN PRODUCTION DEPARTMENT

Recording-controlling pyrometers: 4 L & N "Micromax."
Indicating-controlling pyrometer: 1 Foxboro.
Control equipment under command of above instruments: "Hevi-Duty" and "Martin."
Recording Pyrometers:—3 Brown; 5 L & N Standard.
Indicating Pyrometers:—2 L & N; 1 Foxboro; 1 "Hold-Heet."
"Low" Temperature Indicators: 1 Bristol, 1 "Hold-Heet."
1 L & N Potentiometer
1 Foxboro Testing Galvanometer.

Instruments at KYW, Philadelphia

By E. H. GAGER

Plant Manager KYW
Westinghouse E. & M. Co.

IN this article describing the installation of instruments in the new Westinghouse radio broadcast transmitter installed for KYW in Philadelphia, no attempt will be made to describe the transmitting equipment nor the many circuits which are used in a modern transmitter, as these subjects have been thoroughly covered elsewhere.

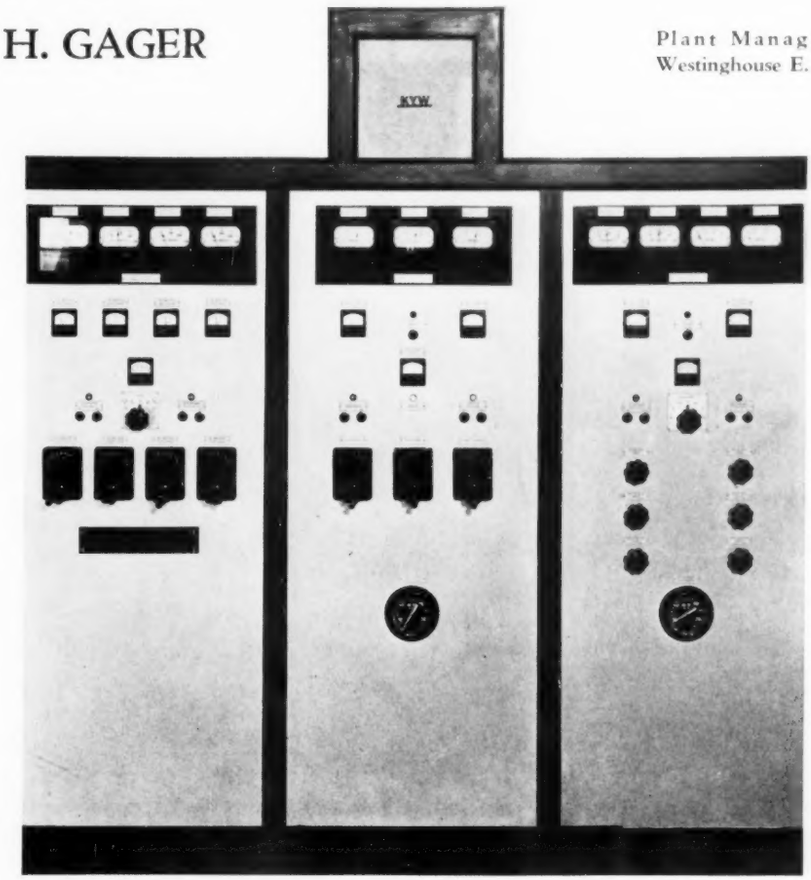

Fig. 1. Modulator and Radio Frequency Amplifier Control Panels. From left to right, Panel 1, Intermediate Radio Frequency Amplifier Control; Panel 2, Final Radio Frequency Amplifier Control; Panel 3, Modulator Control.

A modern radio transmitter comprises, in addition to specially built radio apparatus, certain standard items of power equipment, all of which have specific functions in the control and supply of vacuum tube circuits. Since the life and performance of vacuum tubes are dependent upon the accurate maintenance of definite standards of voltage and current, it is essential that proper instruments be provided to maintain these standards.

In the KYW transmitter, instruments are provided for the following purposes:

Measuring 60-cycle a-c. power, 5 to 2300 volts;
Measuring 8200-volt d-c. power;
Measuring current and potential in all vacuum-tube circuits;
Measuring radio-frequency current in power amplifier and antennae;
Indicating cooling water temperature and pressure;
Measuring total time;
Indicating program level;
Indicating percent modulation;
Checking frequency;
Indicating phase displacement of radiators.

The power supply for the transmitter is obtained from the power company at 2300 volts, 3 phase, 60 cycles. Measurements of current, power and voltage involve the use of potential transformers, current transformers, voltmeters, ammeters and wattmeters—all similar to those of other industrial installations and hence requiring no detailed description here.

High-voltage direct current for the operation of the high-power vacuum tubes is derived from a 6-phase rectifier using hot-cathode mercury vapor tubes. For 10-kilowatt operation, the d-c. potential of this rectifier is 8200 volts. A voltmeter (with multiplier) indicates the voltage of this circuit.

Two WL 848 modulator tubes and two WL 207 power amplifier tubes are supplied from this 8200-volt circuit. An ammeter is used in the plate circuit of each tube to indicate the plate current, which is in the order of 0.9 amp. Since these circuits are at a potential of 8200 volts above ground, the instruments are mounted on Micarta panels recessed in the switchboard, with panels of plate glass covering them to prevent accidental contact. (See Fig. 1)

In the operation of vacuum tube amplifiers, it is desirable to know the value of the grid current in each tube. Therefore, the grid circuits of all tubes in the intermediate and high power amplifiers are provided with milliammeters. It also is necessary to check the negative grid potential of vacuum tube amplifiers at frequent intervals, but is not essential to have a voltmeter permanently connected to the grid circuit of each tube. Two voltmeters, each with a suitable multi-point dial switch (right and left panels, Fig. 1) are used for checking all bias voltages and plate voltage of the intermediate amplifier tubes.

The radio-frequency current is not subjected to measurement until the final stage is reached. An ammeter with external thermocouple is used to measure the "tank" current in the final stage. (Center panel, Fig. 1.) In many installations, an ammeter is used in the "tank" circuits of the lower power stages, but we find that the plate and grid instruments provide sufficient indication of the performance of these amplifiers.

In the operation of high-power vacuum tubes, it is necessary to circulate distilled water through the tube jackets in order to dissipate the heat incident to the operation of such tubes. Cooling water temperatures are indicated by dial thermometers (Fig. 1) provided with

contacts to operate alarms and to shut down the transmitter in case of excessive water temperature. A pressure gage which indicates the water pump pressure will quickly show up any clogged condition of the system.

It is important that accurate records be kept of the hours of service of vacuum tubes, since these tubes are guaranteed for a certain number of hours of life. For this purpose a synchronous clock provided with integrating dials is connected to the filament bus, and when a new tube is placed in service, the total time meter reading is entered on the tube record card. When the tube burns out or fails in service, this reading is again taken and entered on the card, thus securing an accurate measurement of the hours of service.

The life of a vacuum tube depends largely upon the accurate maintenance of the rated filament potential. In our transmitter the filaments of all tubes, from the smallest to the largest, are operated on alternating current. To eliminate the necessity of regulating the voltage of each filament circuit for every change in line voltage, all filament transformers were connected to a common 110-volt bus. By means of suitable resistors in the filament transformer primary circuit, the filament circuits were adjusted to the proper potential with a standard filament bus voltage, using a low-reading portable a-c. voltmeter for this purpose. An induction regulator controls the potential of this filament bus; and an indicating-and-recording voltmeter with a chart speed of 3 inches per hour (upper left, Fig. 2) records all deviations from standard voltage. The other recorder on that panel measures the d-c. power input to the final radio-frequency amplifier and is invaluable in determining the length and time of interruptions.

The antenna system at KYW consists of four vertical quarter-wave antennae or radiators, each consisting of a 200-ft. steel pole mounted on a 45-ft. wooden base. No horizontal wires connect these poles at the top, each one being an independent vertical radiator. In order to measure the current radiated from each tower, a 15-amp. thermocouple is placed in the antenna circuit at the base of each tower. The four sets of thermocouple leads are extended to the transmitter house, a distance of approximately 575 feet, to the four indicating instruments shown in Fig. 2.

The four vertical radiators are placed at the corners of a rectangle 1·2 wave-length long and 1·3 wave-length wide, in order to create a field pattern shaped like a figure 8. The shape of the field pattern, however, depends upon certain phase relations between the vertical radiators. This phase displacement can be governed by the operation of variable capacitors located in a tuning house in the base of each tower. These capacitors are motor operated from the switchboard in the transmitter building. In order to check the phase relations of the different units, radio frequency from each tower is fed back through a pair of wires from each tuning house to switches in the transmitter room. By means of these switches, the output from any radiator can be connected to the plates of a cathode-ray tube (center of Fig. 2). By connecting the output from one tower to one set of plates and the output from another tower to the other plates, the phase relations of the two radiators can readily be observed. This indication is important in the initial adjustment and subsequent checking of the field distribution pattern.

An important function in radio broadcasting is the measurement of the program level, or the amount of audio-frequency power being supplied to the transmitter. The measurement of audio-frequency is accomplished in two ways: the first is the use of a galvanometer in the plate circuit of a vacuum tube, the grid of which is supplied from the audio-frequency source. The scale of this instrument is arbitrarily calibrated in decibels. The other method is the use of a transformer with a high impedance primary, which is connected across the audio-frequency source. The secondary of this transformer is connected to a d-c. galvanometer through a small "Rectox" unit. This scale, too, is calibrated in decibels. The latter method is the more accurate, because it does not depend upon the changing characteristic of a vacuum tube which, in time, will show a loss of plate current, due to loss of filament emission.

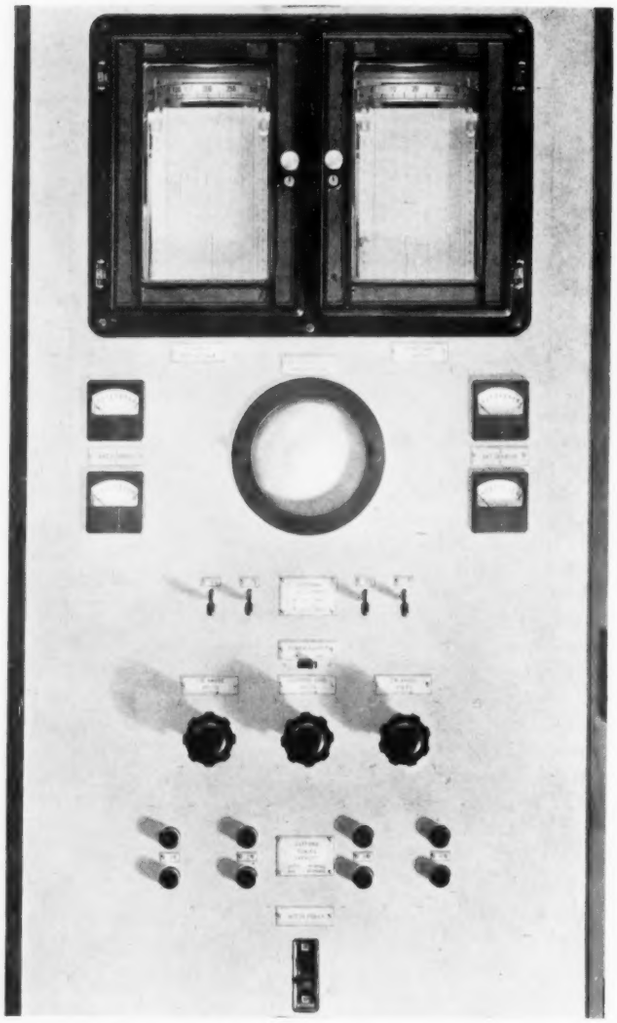

Fig. 2. Antenna control panel showing radio frequency instruments operating from thermocouples remotely located at base of antenna towers. Also cathode-ray oscilloscope for properly phasing directional antennas. Indicating-recording instruments at top measure a-c. filament bus voltage and d-c. power input to final radio frequency amplifiers.

Another important factor in the operation of a broadcast transmitter is the maintenance of a proper percentage of modulation. It is important to modulate the transmitter as high as possible in order to over-ride the noise level and give good reception at the fringes of the reception area. However, care must be exercised not to modulate high enough to cause distortion or poor quality. Usual practice is to modulate 75 to 80% on normal peaks with occasional peaks hitting 100%. The percentage of modulation is measured at KYW with a cathode-ray oscilloscope, Fig. 3. One pair of plates is excited by radio frequency from a pick-up coil located near the

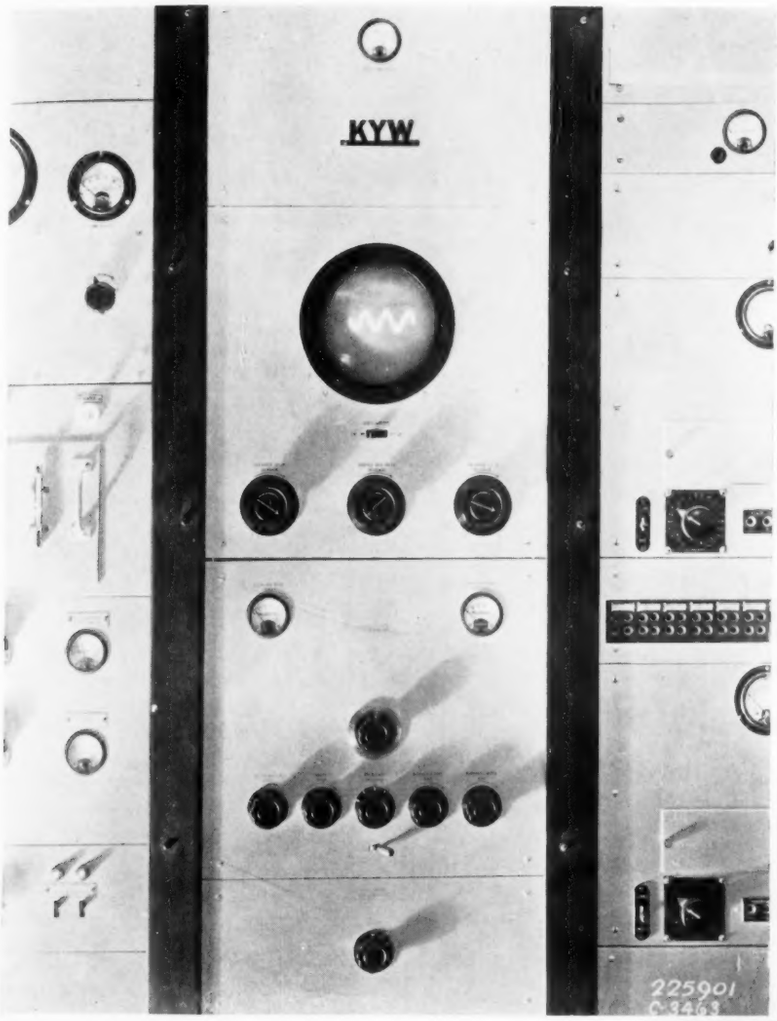

Fig. 3. Cathode-ray oscilloscope for general monitoring purposes.

power amplifier; the other pair by a sweep circuit. The pattern impressed on the screen is the envelope of the modulated radio-frequency output of the transmitter. When the amplitude of the modulated wave is equal to twice that of the unmodulated wave, the modulation has reached 100%. With normal program input, the peaks will of course recur too rapidly for the eye to measure their amplitude, but when the modulation exceeds 100% by even a small amount, bright spots will appear on the screen at the base line of the curve, indicating modulation in excess of 100%.

According to the best practice in modern radio broadcasting, the studio control room is responsible for the program level supplied, through telephone circuits, to the transmitter, which is usually located some miles away. If the program is at normal level leaving the studio control room, the transmitter should be modulated the proper amount. However, slight changes in amplifier characteristics, telephone cable constants, or improper setting of the gain controls may cause improper modulation. In order to keep a constant check on this condition at KYW, a high grade superheterodyne radio receiver is installed in the studio master control room. By coupling a cathode-ray oscilloscope to the plate circuit of the intermediate amplifier, a modulated radio frequency pattern is impressed upon the cathode-ray screen. This pattern will show the percent modulation of the transmitter in the same manner as on the cathode-ray tube used at the transmitting station. In this way, the engineer in the master control room can keep a constant check on the transmitter modulation and adjust the program to the proper level.

The most exacting and perhaps the most important of all measurements in radio broadcasting is the exact determination of the carrier frequency. When it is understood that we are required by law to keep within 50 cycles of our assigned frequency of 1,020,000 cycles, it will readily be seen that great care must be exercised in the equipment used for this purpose. The initial radio frequency is developed by a piezoelectric quartz crystal accurately ground to a thickness which allows it to oscillate at the proper frequency—in this case 1020 kc. This crystal is placed between two metal blocks which are mounted in a heat-insulated thermostated chamber which is also placed inside another temperature-controlled chamber containing the first two stages of amplification. The maintenance of the proper frequency is dependent upon the mainte-

Continued on page 42

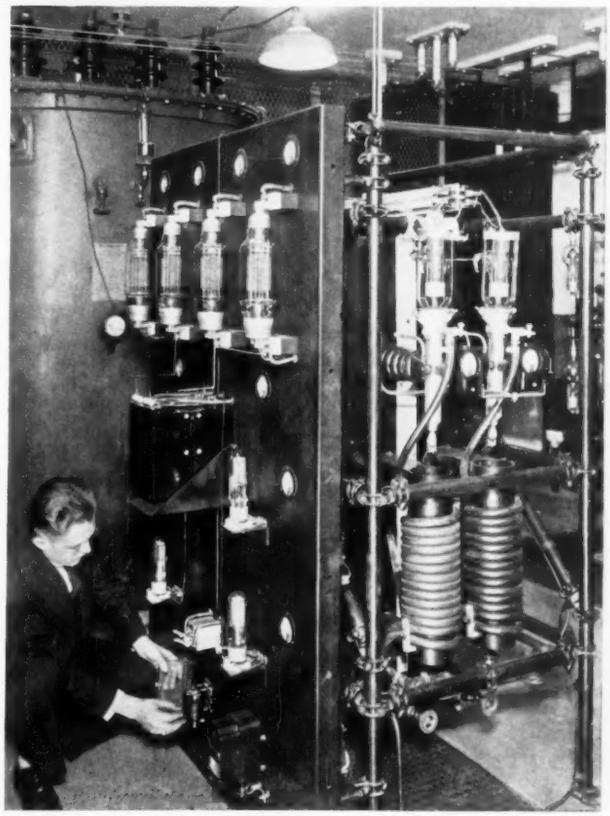

Fig. 4. Modulator unit illustrating the use of plate current instruments mounted directly on the water jackets of the modulator tubes—supplementing the modulator totalizing plate current instruments mounted on the modulator control panel shown in Fig. 1. Although not necessary for routine observations, these and the other instruments on the unit are used for adjustment purposes.

Manometer Errors due to Capillarity

By RICHARD G. FOLSOM

Instructor in Mechanical Engineering, University of California, Berkeley, Calif.

THIS investigation was undertaken to provide data required for the selection of manometer tube size when making measurements within a given limit of error. The material was collected from published reports of mathematical and experimental researches with the addition of some approximate tests.

MATHEMATICAL EQUATIONS AND EXPERIMENTS

The formula derived in elementary text books on physics for the capillary rise in small-diameter circular tubes is

$$h = \frac{2\sigma}{r(W_1 - W_2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where h = capillary rise, inches.
σ = surface tension, pounds per inch.
r = radius of tube, inches.
W_1, W_2 — unit weight of fluids in contact, lbs./in.^{3}

Substituting values for water and air, equation (1) becomes

$$h = \frac{0.046}{2r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This is the expression given by Gibson[1] and Marks.[2] The upper limit of applicability of equations similar to (2) is about 3/32″ tube diameter.

Lord Rayleigh[3] gives an equation for diameters greater than 23/32″ while Sugden[4] has computed several points in the intermediate region. The curve in Fig. 1 presents the results in terms of the ratios h/a and r/a where

$$a^2 = \frac{\sigma}{W_1 - W_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Since the ratios are dimensionless, the graph can be used with any consistent system of units. (See Table I for values of a^2.) Using pure liquids (as triply distilled) and clean surfaces, several investigators have checked the graph within experimental error.

APPROXIMATE TESTS

Since the surface tension and thus the capillary rise depends upon many factors,[5] for example, impurities in the fluids or on the surface of the tube, attempts were made to measure the rise under conditions similar to normal engineering usage. Levels were determined with a cathetometer reading to 0.0001″ for a series of different diameter commercial glass tubes. The reference level was taken in a 1.71″ inside diameter tube so that the

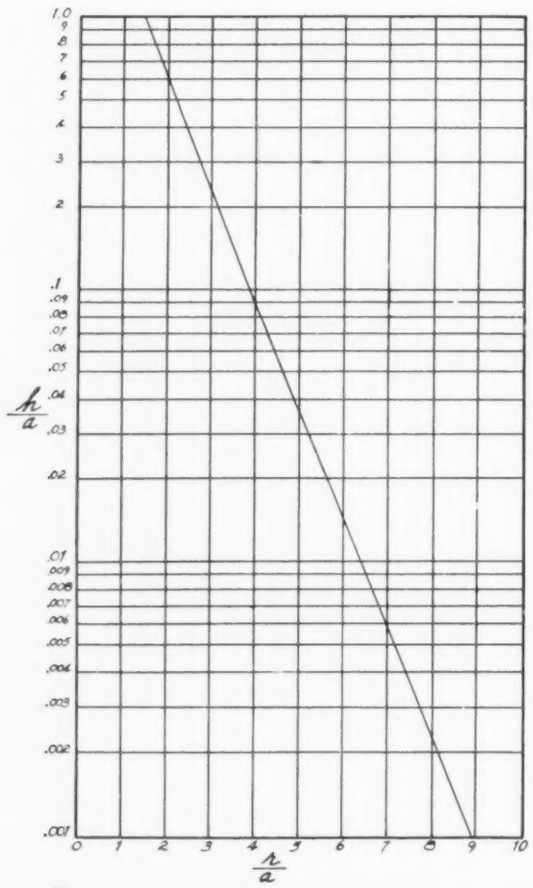

Fig. 1

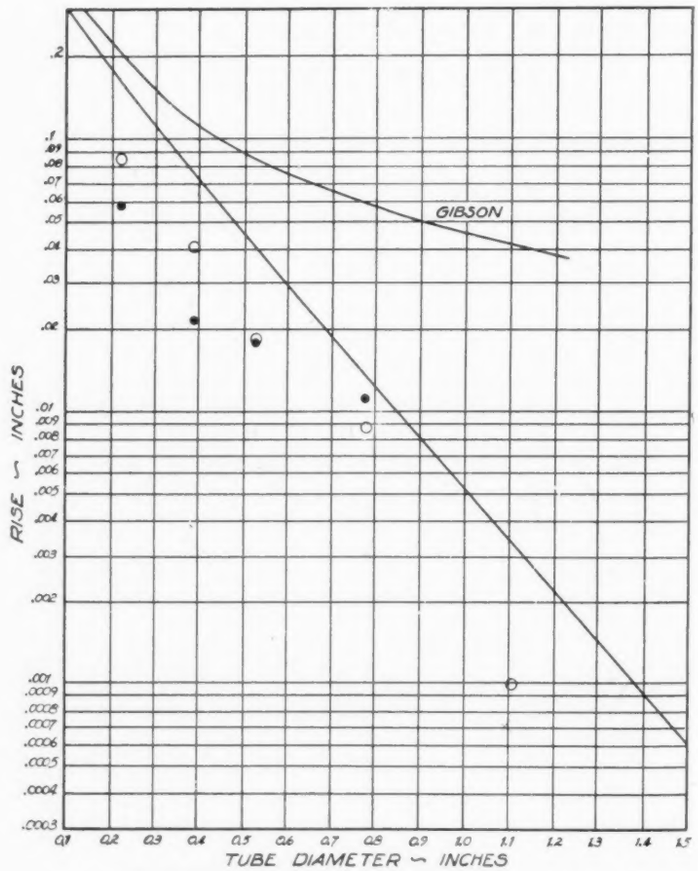

Fig. 2. Capillary rise with water-air.

TABLE I*

	Metric Units		Convenient English Units
	a^2(mm.^{2})	σ(dynes/cm.)	a^2(in.^{2})
Water	7.44	72.74	0.01152
Benzene	3.36	28.88	0.00521
Ether	2.44	16.96	0.00378
CH Cl_3	1.86	27.14	0.00288
C Cl_4	1.71	26.77	0.00265

Liquids in contact with air and temperature of 68° F.

*Data from Richards and Carver, *Journal American Chemical Society*, Vol. 43, 1921, pages 827-847.

rise was negligible as compared with the others. The tubes were wiped clean and partly filled with tap water and again with dirty water from the hydraulic laboratory storage tanks. The experimental points are plotted in Fig. 2 with the water-air graph determined from Fig. 1 with $a^2 = 0.01152$ in.^{2}. The graph of equation (2) is included to indicate the error involved in its application.

Measurements were made with tap water in contact with mercury which had been washed with nitric acid and filtered. The results are plotted in Fig. 3 with the mercury-water graph determined from Fig. 1 with $a^2 = 0.00473$ in.^{2}. The capillary rise in this case is negative.

Attempts to measure the rise with carbon-tetrachloride colored with oil red dye and water were unsatisfactory as the shape of the boundary surface varied and the rise changed with time in a single tube.

The curves of Figs. 2 and 3 are approximated closely by the equations

$$\text{water-air,} \qquad h = \frac{0.400}{e^{4.37d}} \quad . \quad . \quad (4)$$

$$\text{mercury-water,} \qquad h = \frac{0.281}{e^{6.80d}} \quad . \quad . \quad (5)$$

where d is the inside tube diameter in inches.

CONCLUSIONS

Simplified formulas of the type given by Gibson and Marks for the capillary rise in small tubes cannot be applied for diameters greater than about 0.1″.

When a^2 is known, the theoretical rise or depression can be computed from the graph of Fig. 1. Approximate equations for water-air and mercury-water in glass tubes are given and the tests indicate these values to be valid for normal engineering conditions.

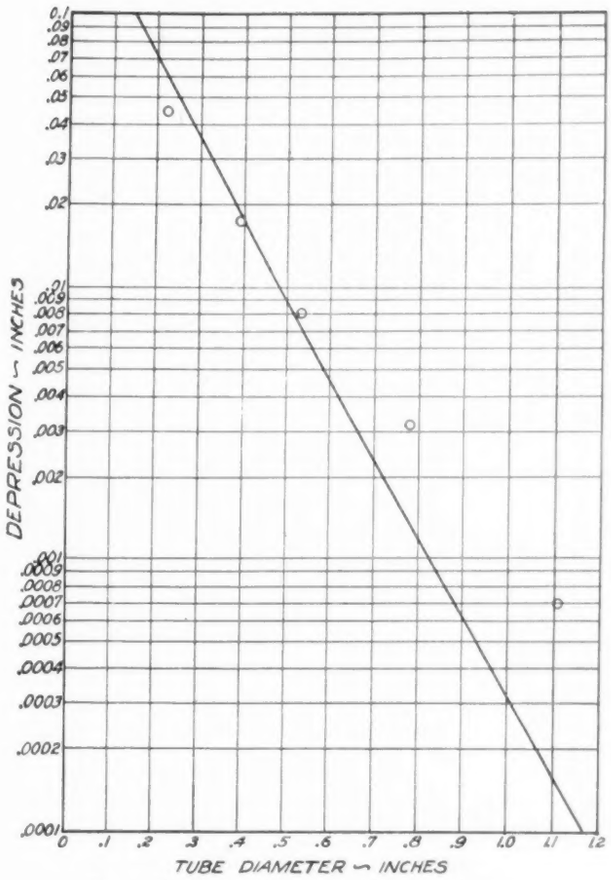

Fig. 3. Capillary depression with mercury-water.

These data provide a basis for the selection of manometer tube size for measurements within an allowable error. Likewise, they indicate the error to be expected with a U-tube when the tube diameters differ.

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[1]Gibson, Hydraulics and Its Applications, Constable, London.
[2]Marks, Mechanical Engineers' Handbook, McGraw-Hill, New York.
[3]Lord Raleigh, *Proceedings of the Royal Society of London*, Vol. 92, 1915-16, pages 184-195.
[4]Sugden, *Journal Chemical Society*, Vol. 119, 1921, page 1483.
[5]Eagle and Wilson, *Civil Engineering*, Vol. 4, No. 1, 1934, pages 30-32.

Slip Measurement on Wound-rotor Induction Motors

By H. R. REED

Associate Professor of Electrical Engineering, Michigan College of Mining and Technology

THE slip of wound-rotor induction motors may be determined by connecting a zero-center millivoltmeter across two of the slip rings, the rotor being connected through its normal external resistance. Each time the rotor slips a pair of poles the millivoltmeter, which follows the oscillations of the rotor voltage, will complete a cycle, that is, it will travel from zero to a positive maximum then to a negative maximum and back to zero. The slip, in cycles per second, is then determined and the slip in r.p.m. calculated from the formula

$$N = \frac{f \times 120}{p},$$

where N is the rotor slip in r.p.m., f the slip frequency, and p the number of poles of the machine. When using this method to determine the percent slip the synchronous speed of the motor field must be known. This may be found, either by measuring the speed of a synchronous motor run from the same line, or measuring the frequency of the line voltage and calculating the synchronous speed.

This note supplements the article by Schilling and Williamson in our August 1935 issue, where a new slip measurement method was proposed and others (not including this one, however) were referred to.—EDITOR

Insert a variable low resistance in series with the millivoltmeter to control the amplitude of the swing. *Do not* have the millivoltmeter connected across the slip rings while the machine is coming up to speed.

Timing Base Equipment for Cathode-ray Tubes

Eighth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in the July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

Having mounted the tube and arranged a power supply, the next requirement is a means for obtaining a time sweep that can be used to produce the horizontal deflection. Most oscillographic work having previously been done with galvanometer types wherein all measurements are made with respect to "time," the cathode-ray oscillograph is called upon to duplicate many of the records produced by the other. As experience is gained, it is found that many problems are more readily solved without a time base; but in many cases such equipment remains indispensable. Various types will be described, in order of complexity.

There is nothing about the cathode-ray tube itself that is capable of indicating or recording time intervals.

In certain examples of the vibrating-mirror type of oscillograph the time scale is obtained from light flashes produced at definite intervals by a synchronous motor, and the record is continuous and can be extended to as long a strip of film as necessary.

With a cathode-ray oscillograph the reason why a timing oscillator is required is the limited fluorescent screen area available in the tube, so that the diagram must be "folded up." Imagine that the true or extended diagram is on a long transparent film, many times longer than the screen diameter. There are several methods by which the folding can be done (see Fig. 11):

(1) Wrap this film around a transparent cylinder and to look through the whole assembly from the side;

(2) Fold the film by creasing it at regular intervals;

(3) Cut the film into equal sections and pile up these successive portions.

By using any of these methods a complete record may be viewed in a limited area but the resulting view will be more or less complicated compared to the original.

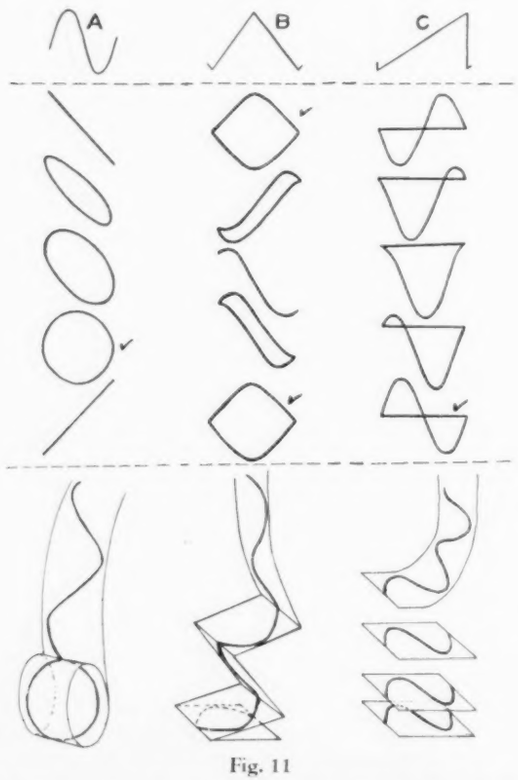

Fig. 11

If sine-wave a.c. is connected to one pair of the tube's deflection plates the curves shown in each column can be produced by connecting to the other pair a timing wave of the same frequency, and of the shape shown above the dashed line.

11A is a sine-wave and produced the "rolled up" effect.

11B is a saw-tooth wave and gives the zig-zag folding (see text).

11C is a snap-back wave and produces the cut-and-pile effect, with the straight snap-back line added.

11A and 11C are the most useful.

The mechanical equivalent of each folding method is shown at the bottom of the column. The folding is in each case producing the curve checked in the column above.

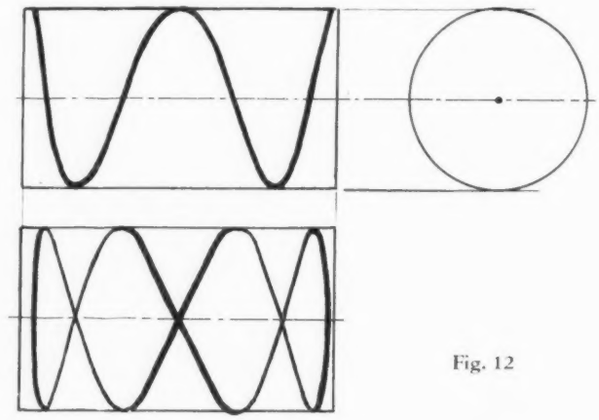

Fig. 12

To analyze the diagram necessitates a knowledge of which method was used in the folding process. This folding is done automatically in the cathode-ray tube by the action of the timing oscillator. If this oscillator gives a sine wave (see Fig. 11A) the resulting diagram takes the form of (1) in the above list. In Fig. 12 an elongated ellipse is so depicted. If the waveform is sawtooth, Fig. 11B, the effect is as if folded by method (2) and if the waveform is like that shown in Fig. 11C, the "cut and pile" method (3) is simulated. The latter type of waveform is usually called a linear time base, and its production will be described in the following sections.

KEY CONTROLLED SINGLE SWEEP EQUIPMENT

If a capacitor is connected across a direct current potential it becomes charged almost instantly. When, however, a resistance is placed in the circuit, the charge accumulates at a slower rate, and the voltage across the capacitor builds up according to an exponential law. If one pair of deflection plates is connected across the capacitor the spot will drift across the screen, at a rate depending upon the values of R and C and upon the charging voltage. If a key or switch connected across the capacitor is closed, the spot will return instantly to

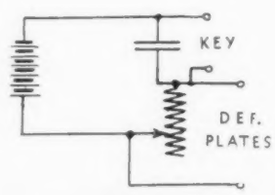

Fig. 13

the starting point. If this key is controlled mechanically either at a fixed rate or else in synchronism with the mechanism under test, an extremely simple time base deflection is obtained. See Fig. 13.

The main difficulties found with this equipment are that the higher sweep frequencies are not easy to obtain, and that the movement of the spot is not linear with time. The latter problem can be solved if the resistance used in the charging circuit is replaced with a device that will keep the charging current constant, regardless of the counter-emf produced by the charge on the condenser. This characteristic is readily obtained by substituting for the resistor the plate resistance of a vacuum tube. In a two-element tube, for instance, the plate current remains constant regardless of the plate voltage, whenever the filament emission is reduced to a value where it constitutes the main control over the plate current, usually termed "saturation."*

The charging rate on the capacitor, therefore, is readily controlled by adjusting the filament temperature (this filament must be heated by d.c.). In order to eliminate a battery for this purpose, it has been usual practice to utilize a tetrode or a screen pentode instead

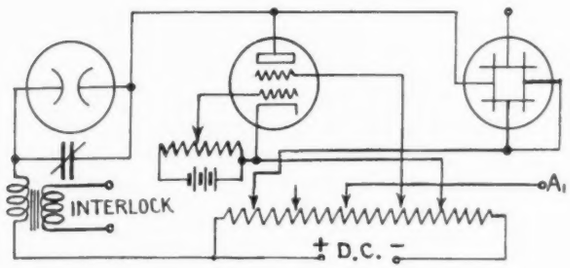

Fig. 14

of a diode (Fig. 14), and to connect the control grid so that it is the controlling element in the determination of the plate current, regardless of minor variations in the filament temperature. The cathode can then be of the indirect-heater type and with proper precautions can be operated on a.c. These tubes can be used in any of the following circuits that use the capacitor charge principle.

MOTOR DRIVEN TIME BASE

When the required frequency range of the time base is small or when a fixed frequency is required, a motor-driven circuit is possible. A synchronous motor is useful in investigations of conditions that take place at the frequency of the a.c. line.

An early method is the motor-driven potentiometer[10], wherein a circular potentiometer resistor that is continuously rotatable is coupled to the shaft of the motor. The mechanical difficulty of designing and constructing the resistance element for long service life has prevented this method from receiving much attention. One arrangement is a carbon ring, cut radially at one point, and having a resistance from one end to the other (due to the cut) of from 25,000 to 100,000 ohms.

*It has been noted that the term "saturation" as applied to vacuum tubes is sometimes wrongly interpreted. In the case of a diode with a filament, when a copious emission is made possible, the plate current is largely proportional to the plate voltage. At lower temperatures the emission is less and the current largely depends on the filament temperature only (except for very low plate voltages). In this application the filament must be operated at a reduced temperature. In the case of a pentode tube with indirectly heated cathode, use is made of the "virtual" cathode (which depends upon the bias of the control grid) the position of which determines the plate current.

[10]Zenneck. Transformation eines Wechselstromes. *Annalen der Physik & Chemie*, Vol. 69, 1899, pages 838-853.

In another method the charge of the capacitor is shorted periodically by a motor-driven commutator upon which one or two brushes rest lightly. To prevent undue sparking a small resistance is placed in series with the brushes.

In the design of the *R-C* circuit, it is quite possible to use as the charging potential the plate supply voltage of the cathode-ray tube, which of course is greatly in excess of that required to deflect the spot across the screen. It can be shown, however, that the initial 25% of the exponential charging curve of the capacitor is substantially a straight line, so that linearity of the time base can be obtained with an ordinary resistance in the circuit.

Analysis shows that the product $(R \times C)$ is the factor that must be considered so that a variety of values of either R or C can be used. It is first necessary to determine the voltage required to deflect the spot diametrically across the tube screen. In many tubes this is approximately equal to 15% of the anode voltage, but in any case is obtainable from the manufacturer's data, or from formulas given in preceding articles. If the value of the percentage is designated "d", then the value of $R \times C$ can be obtained from the following table:

$D =$	10%	15%	20%	30%	40%	50%
$RC =$	$\frac{9.5}{n}$	$\frac{6.25}{n}$	$\frac{4.54}{n}$	$\frac{2.81}{n}$	$\frac{1.95}{n}$	$\frac{1.45}{n}$

Here the values are in megohms and microfarads, and the value of "n" in sweeps per second. The capacitor should have low internal resistance, should be non-inductive, and should be capable of handling the entire anode potential without breakdown. The above data hold in any circuit where the discharge rate is not controlled by the RC circuit itself but by some mechanically operated switch operating at the frequency "n".

Another circuit which has been used by the author is shown in Fig. 15. It is useful when the frequency of the time base is 60 cycles or less, the limiting factor being the speed of the relay. Here the RC circuit has a considerably lower time constant than the $R'C'$ circuit, this latter being designed according to the above table of RC constants. (The theory of the neon tube circuit shown in Fig. 15 will be taken up in the following sec-

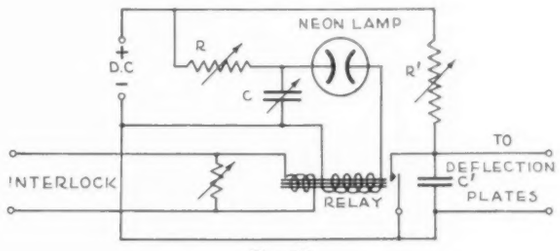

Fig. 15

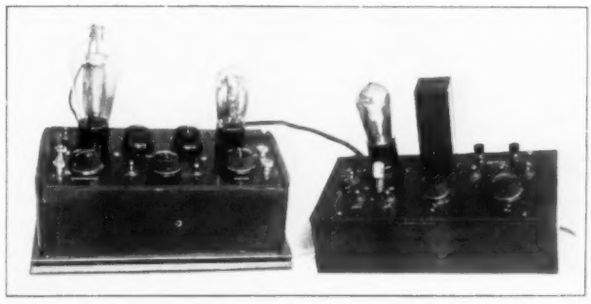

Fig. 16

tion.) A secondary winding on the relay provides an easy method of synchronization with the frequency under investigation. The timing wave could be set for an equal frequency or some sub-multiple as desired. The main winding on the relay had about 11,000 turns of No. 38 wire with a resistance of 500 ohms. A photograph of one application of this circuit appears in Fig. 16.

Obviously, additional relay contacts can be so connected that one pair of deflecting plates is shorted during the restoring interval to delineate the axis for measuring purposes.

A variation of this circuit is to charge the capacitor rapidly when the contacts are closed, and to utilize the slow discharge for the timing wave.

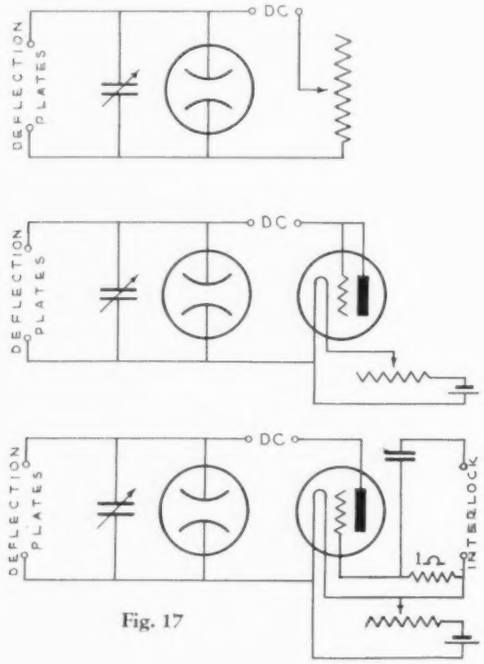

Fig. 17

NEON TUBE OSCILLATORS

Several popular timing wave oscillator circuits have been adapted from the well-known neon tube flasher circuit. This circuit is of the capacitor charge type, and utilizes the feature that, as the voltage on the capacitor builds up, the neon lamp connected across it breaks down and dissipates a portion of the charge. As the voltage drops the lamp is extinguished and the cycle repeats. The main disadvantage with this circuit is that the capacitor is not discharged to zero, but fluctuates between two values relatively close together, depending upon the characteristics of the neon tube.

The total voltage variation, therefore, is hardly sufficient to give full-scale deflection with the usual cathode-ray tube. Investigators have disclosed a large number of circuits, three of which are shown in Fig. 17. The use of the constant-current charging device heretofore described is shown in two of these.

Not only will the usual neon lamp, such as the type G-10, function in this circuit, but many other types of gas-filled tubes can be used as well. In using ordinary neon lamps the series protective resistance usually sealed up in the base should be removed. Excellent results have been obtained from the voltage regulator tube (such as the 864) and from gas-filled rectifier tubes such as the Raytheon type BH, etc. The tubular neon-filled "Tunalite" is likewise satisfactory.

Although these circuits have a low output potential (without amplification) for time base use, they find applications also as surge or pulse generators in other measuring applications.

The actual variation from linearity depends upon the relation between the values of C, R, and E. It usually is desirable to have the applied voltage much higher than the value required to operate the glow lamp, and then to use a larger capacitor and higher resistance to obtain the desired frequency.

With so many variable factors affecting operating conditions, several combinations are usable for a given frequency. In Fig. 18 generalized curves show the voltage increment across a condenser with several values of RC (assuming that R is a fixed resistance). Two horizontal lines across these curves indicate the kindling or breakdown potential and the extinguishing potential of the glow lamp. The distance between the ordinates from the points of intersection of any of the curves with these horizontal lines represents roughly the time of one cycle, or of one sweep of the spot across the screen.

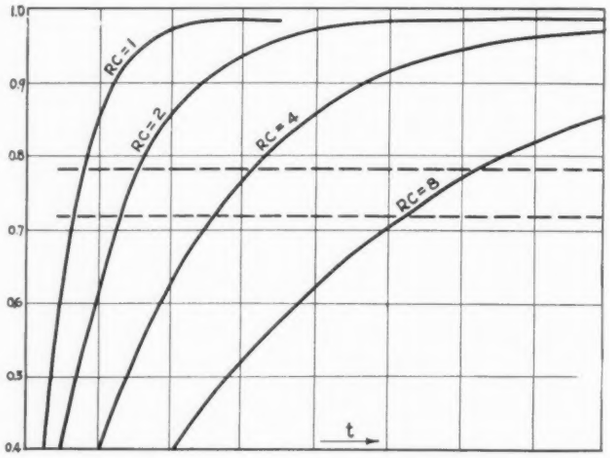

Fig. 18

The other variable factor is the value of the voltage E, which may be any value in excess of P (referring to Fig. 19). For a given frequency and a given maximum voltage E, there is only one value of RC that can be used. In theory it makes little difference whether the value of R or C is made large, and the other small. In practical cases, however, the internal impedance of the deflection plates, although high, produces serious changes in the circuit so that it is desirable to use large values of C and a lower R in order that the shunting effect of the cathode-ray tube be less important.

Since it is the section of the curve between the two horizontal lines (in Fig. 18) that determines the waveform, it is important that this sector be as straight as possible. It will be noted that if the frequency is changed by varying the voltage only, the operating point for certain frequencies will be at the bend of the curve, so that better results would be obtained by controlling the value of RC, keeping E substantially greater than P. Constants can always be selected that will give fair linearity for a particular frequency without resorting to a "tube" resistor. It is only when the oscillator is made to cover a range of frequencies that difficulties occur in securing linearity.

An extremely sharp snapback is impossible if the capacitor has appreciable internal resistance or in-

ductance. Highest grade non-inductive capacitors must be used in these circuits. Interesting results are obtained if the internal inductance of the capacitor is such that it resonates at a frequency near to that at which the oscillator is adjusted, in which case the output wave form is approximately sinusoidal.

INTERLOCK CIRCUITS

Any type of gas-filled lamp has certain vagaries in its operating characteristics which may affect the frequency. In order to prevent the oscillograms from drifting, some type of synchronization is required, by which the discharge lamp is triggered off at definite intervals, thus establishing an interlock between the circuits.

This is especially required in low-intensity cathode-ray tubes when a diagram must be repeated on the screen until it can be copied, measured, or photographed. One method for this stabilization utilizes a small emf from the test circuit applied to the grid of the tube acting as the control resister of a neon oscillator, as in Fig. 14. This potential is applied through a small capacitor or

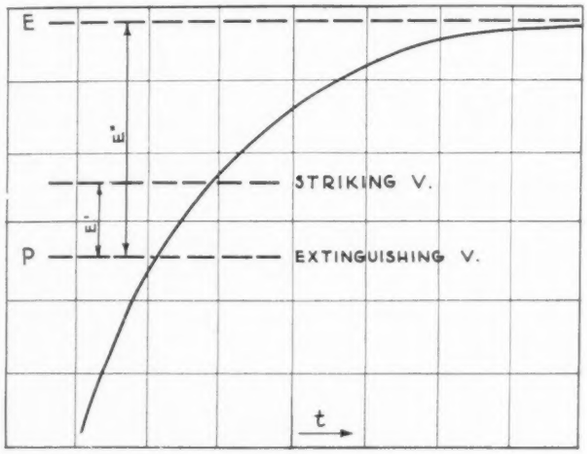

Fig. 19

transformer or through a stage of amplification to prevent a small back coupling from the oscillator from introducing undesired effects into the circuit under investigation. Since the timing wave is usually set at some exact sub-multiple of the frequency studied, at several intervals during the timing cycle small voltage pulses are applied to the timing wave oscillator circuit. During a large portion of the cycle these pulses have no effect, but if introduced at a time when the tube is about ready to discharge, the circuit is triggered off.

It usually is best practice to adjust the flasher circuit to approximately the correct frequency before the synchronizing circuit is closed.

The success of many oscillographic tests depend upon the ease of synchronization. Usually the wave under measurement is connected to the vertical deflection plates *and* to the synchronization circuit in addition. Two effects occur that must be considered. Pulses from the timing oscillator may kick back into the unknown wave and distort it. Also, the power taken by the synchronization circuit may be excessive. Neither of these effects is important if the power available in the circuit under investigation is large. Otherwise, the synchronization circuit should have a high impedance, such as the input of a vacuum tube. Amplified synchronizing pulses may be necessary where the wave under test is weak.

POSITION CONTROL

Since the normal position of the spot when undeflected is in the center of the screen, in order to keep the diagram on the screen, it is necessary to move the spot initially to one edge before the timing potential is applied, or else to provide a time base whose potential range has an average value equal to zero. It usually is convenient to reduce the voltage on the anode of the cathode-ray tube by an amount approximately one-half the required deflection voltage, thereby producing a control between that voltage and the timing base voltage to shift the position of the picture on the screen as required. This arrangement has been applied to other circuits hereinafter described. Two practical circuits were shown in Fig. 4 of the January 1936 article.

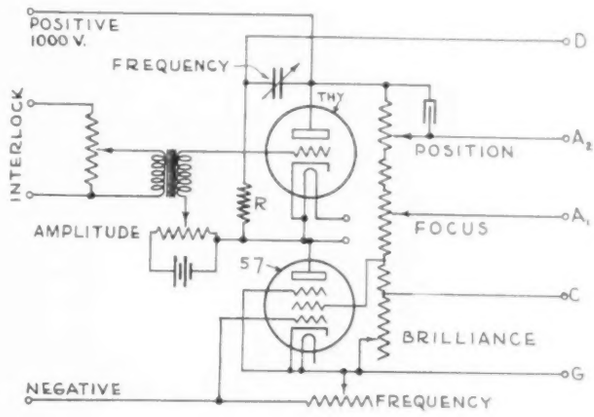

Fig. 20

THYRATRON OSCILLATORS

The substitution of a hot-cathode gas-filled discharge tube, such as a Thyratron, for the neon tube, overcomes most of the inherent disadvantages of the latter. A number of improvements are due to this change: the capacitor is discharged almost to zero, and the breakdown potential is directly controllable, so that the amplitude of the deflection of the time base can be made as large as desired. This amplitude is easily controlled by a simple adjustment of the bias to the grid. The problem of interlocking with the measured frequency is also solved. The capacitor is discharged rapidly and without sparking. A representative circuit is Fig. 20. A single rectifier supplies potentials to both the cathode-ray tube and the time base, which is possible when low potential cathode-ray tubes are used (1000 volts maximum). A few details of certain features follow which refer to this circuit:

The rapidity of the snap-back portion of the cycle depends upon the de-ionizing time in the discharge tube. This depends upon the amount of mercury in the tube. Apparently, best results are obtained with little free mercury at normal temperatures.

In some cases a damped wave oscillation may occur during each capacitor discharge period. While this does not affect the normal operation, it may disturb associated circuits. Shunting the discharge tube grid circuit with a bypass capacitor can be used when it is necessary to eliminate this. The grid circuit resistance should be kept low.

Frequency is usually controlled by adjusting the charging rate to the capacitor (by varying the bias on the control grid of the pentode), or by changing its capacity. For exact linearity over an extended frequency

range, it will be necessary to do both. As the amplitude is varied by adjusting the bias on the discharge tube grid, the frequency is also changed but this is unavoidable without complicating the circuit.

The interlock circuit utilizes a step-down transformer having a ratio of the order of 5 :1, and provided with a static shield between windings. It always is necessary

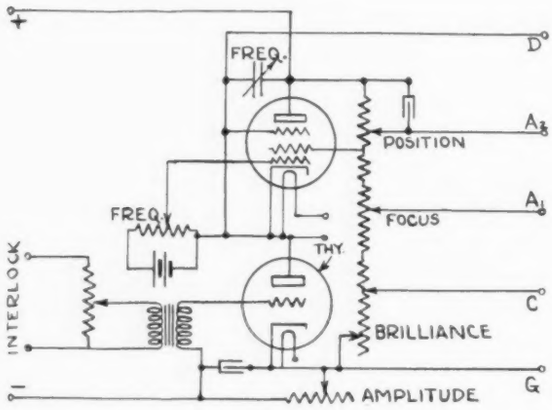

Fig. 21

to adjust carefully the frequency controls so that a minimum of synchronizing potential need be applied to the interlock circuit.

In the circuits described above it has been the usual practice to utilize gas-filled triodes to discharge the capacitor, which has been charging at a definite rate through a ballast tube (Fig. 11). The process can be reversed and the capacitor charged rapidly and discharged slowly, by the simple expedient of connecting the charging capacitor across the ballast tube (the pentode, -57, etc.), instead of across the discharge tube.

(In the next article an important commercial development using this principle will be described.)

The results are the same and there usually is little to choose with either arrangement. Fig. 21 shows one arrangement based on this principle.

OSCILLATOR FREQUENCY CONTROL

In the design of the frequency determining circuit using a Thyratron or similar gas-filled tube, the characteristics of the tube need not be considered in the fundamental design. The following factors are important:

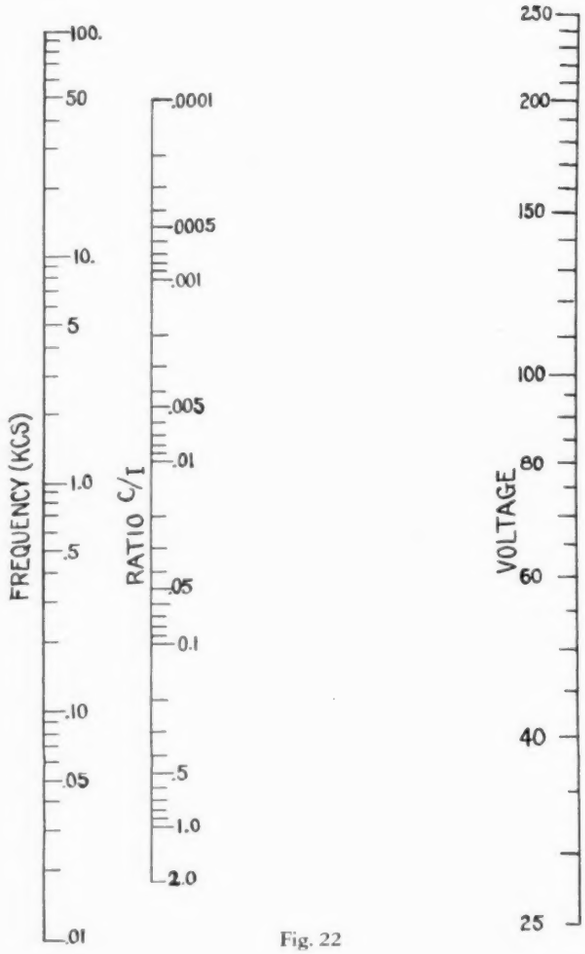

Fig. 22

1. Maximum voltage of the swing, as determined by the required deflection, and the deflection sensitivity of the cathode-ray tube.

2. Required frequency or frequency range.

Application of these data to the nomographic chart, Fig. 22, will provide the value of the ratio C/I. The value of I in milliamperes can be determined from the characteristic curves of the pentode used as the charging resistor, from which the required capacity in microfarads can be computed. The bias on the discharge tube grid must so be adjusted that the discharge occurs when the charge reaches the desired potential.

To be Continued

INSTRUMENTS AT KYW

Continued from page 35

nance of the proper temperature in the crystal chamber, and this temperature, controlled by a thermostat, is never allowed to vary more than 0.1 °C. In actual practice, the variation is much less: since our new transmitter has been in service, the maximum deviation from the assigned frequency has been 2½ cycles, whereas a change of 1° C. would cause a frequency deviation of 20 cycles. In order to keep a constant check on the carrier frequency, we are required to have a deviation monitor unit, approved by the Federal Communications Commission. This unit consists of another crystal oscillator which is adjusted to a frequency 1000 cycles below the assigned carrier frequency. This produces a 1000-cycle beat note in the detector circuit of the deviation monitor, which is used to supply a dial type frequency meter, the scale of which is marked 50-0-50. When the beat tone is exactly 1000 cycles, this frequency meter reads zero. If the transmitter frequency is above normal, the beat note will be above 1000 cycles and the frequency meter will indicate that the frequency is high. Conversely, if the transmitter frequency is below normal, the beat tone will be below 1000 cycles and the frequency meter will indicate that the frequency is low.

The transmitter frequency is measured bi-weekly by the Westinghouse Frequency Measuring Laboratory in Chicopee Falls, Mass., which has facilities for checking our frequency with an accuracy of better than 0.0002%.

In building the switchboards for the KYW transmitter, an effort was made to preserve the symmetry and beauty of the installation. "Type HX" and "RX" instruments were chosen because their shape blended so well with the rectangular switchboard design.

TOTALIZING

Twenty-sixth instalment of "Electrical Measurements and Control." This series began in the January 1934 issue. See announcement on editorial page of November 1933 issue. All rights reserved by the authors.

By PERRY A. BORDEN and M. F. BEHAR
Member A.I.E.E. Editor, *Instruments*

Inseparably associated as it is with other branches of electrical measurement, the subject of totalization has therefore received some attention in earlier parts of this work.[1] This article is designed to take account of those systems and methods of totalization which had not been described, and to present information permitting the characteristics of various systems to be considered on a comparative basis.

In commercial or industrial fields the only electrical magnitudes which it is necessary to totalize are those of power and energy, including of course volt-ampere and reactive volt-ampere measurements. Of course, where the principles of telemetering are involved, the actual totalization may be accomplished on voltages, currents or other electrical variables made representative of these magnitudes. In other branches of industry, however, the totalization of fluid flow grows steadily in importance; and, insofar as this may be accomplished by electrical means, an attempt will be made to describe those systems which have not heretofore been treated in this Part of the Manual.

Totalization may be accomplished by the following methods, each generally suited to a particular class of work:

(1) Multiple-element meters and deflection instruments;
(2) Special instrument transformers and instrument transformer connections;
(3) Mechanical totalization of impulses;
(4) Applications of telemetering principles.

1. Multiple-element Meters and Deflection Instruments

The essential principle of the multiple-element meter for totalizing electric power loads is found in the polyphase wattmeter or watthour meter. In these instruments the electromagnetic reactions representing in value respective power loads whose sum it is desired to obtain are derived from individual measuring

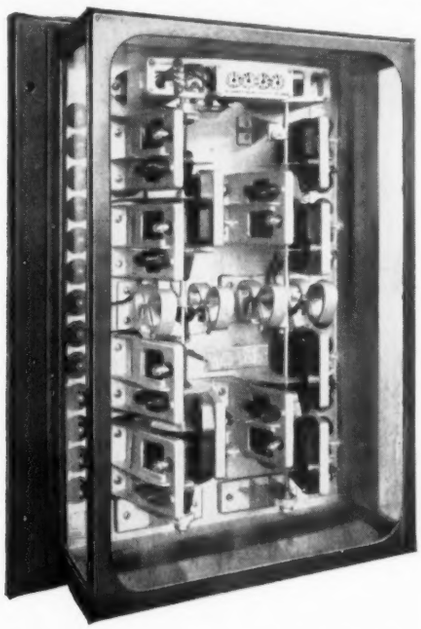

Fig. 45-1

systems, and caused to exert their combined utilizable effects upon a common responding element whose mechanical reaction is determined in any one of the ways common to measuring instruments. Thus there may be produced an indication, a record, or an integration of the sum of any number of individual power loads for which elements may be made to react upon a common deflecting (or rotating) member.

[1] *Instruments:* Sept. 1935, page 235; Oct. 1935, page 258-9; Nov. 1935, page 294; Dec. 1935, page 329; Jan. 1936, page 16.

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Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

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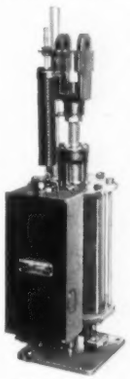

Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

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It may here be noted that the provision of special devices for totalizing integrations (except where telemetering is involved) is not so important as for indications, records, and demands, because a totalization of consumed energy can be obtained at any time by the simple expedient of adding the registrations of a number of integrating meters. Moreover, such numerical totalization (of the readings of watthour meters on separate circuits) is generally more accurate in practice than that obtained with a multi-element meter. Indications, records, and demands, on the other hand, involve the continuous summation of instantaneous values; and, without special measuring devices, the determining of totals generally involves a great amount of clerical work, with final results which cannot approach those of a specially devised totalizing system.

General Electric Duplex Totalizing Meter

Though watthour meters having more than three electromagnetic elements associated with one rotating element are not common, there is available as a standard product a multi-element meter built by the General Electric Co. This meter, shown in its six-circuit form in Fig. 45-1, comprises two rotating elements, each acted upon by six single-phase electromagnetic systems, the revolutions of the two spindles being totalized by differential gearing to produce a registration on a single set of dials.

The use of multi-element *recorders* for electric power loads is common, and several types and makes are in regular use. Since such instruments are sometimes used on heavy loads it is desirable that they have a high degree of precision, and considerable refinement has been reached in applying compensations for sources of error which might safely be neglected in less important installations.

Esterline Induction-type Totalizing Recorder

One of the earliest and most interesting multi-element recorders is that installed in 1917 by the Esterline Co. to handle the 250,000-kw. load of the Keokuk plant of the Mississippi River Power Co.[2] This instrument, Fig. 45-2, is still in operation. It was designed to totalize the output of thirty polyphase generators, and embodies sixty induction-type electromagnetic systems. These impart their joint reaction to a moving element consisting of six annular aluminum plates suspended on a steel wire which not only supports the weight of

[2]Largest Graphic Meter in the World. *Electrical World*, Vol. 70, July 14, 1917, page 90.

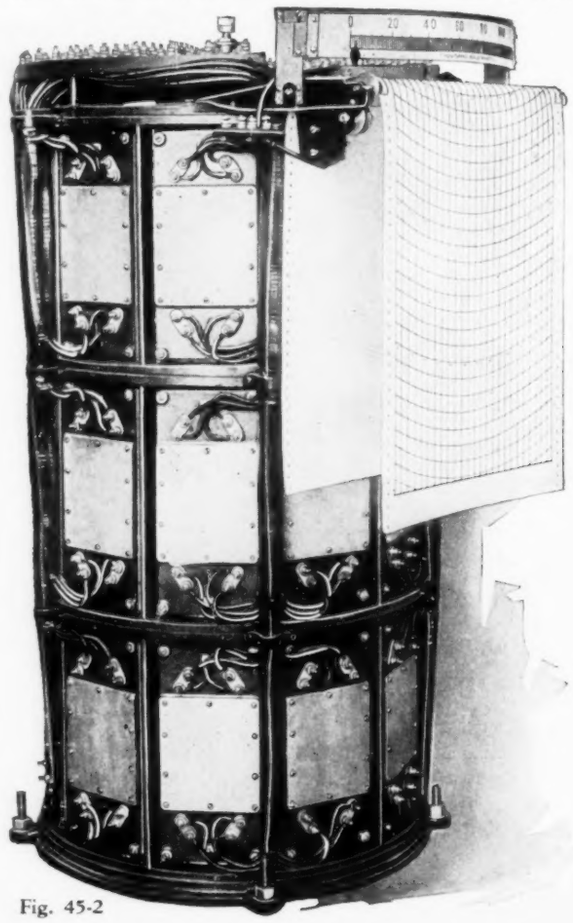

Fig. 45-2

the moving element but also furnishes the greater part of the restraining force. The instrument is built on a unit system in three sections, each containing ten polyphase wattmeter elements so arranged that any one can be removed for inspection or calibration without disturbing other parts. All connections are carried to the top of the instrument, where a circular terminal block having 240 binding posts provides connection to the instrument transformers. The chart width is 12½ inches.

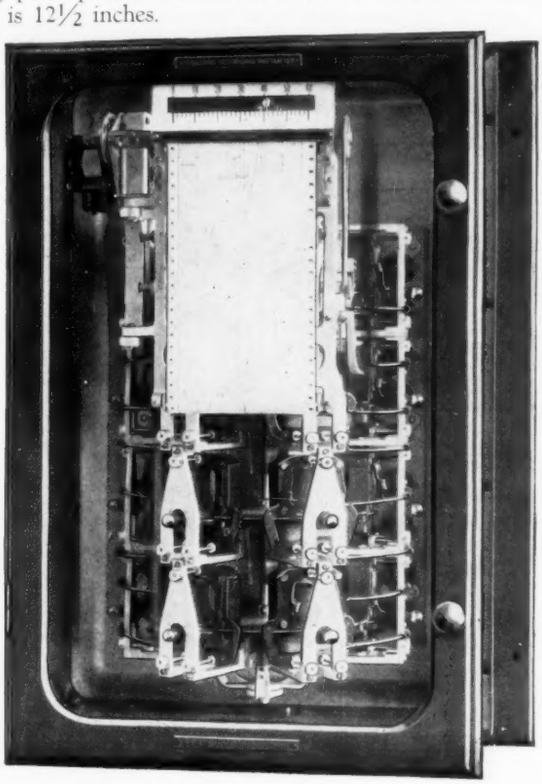

Fig. 45-3

General Electric Totalizing Recorder

The General Electric Co's totalizing recorder, Fig. 45-3, operates on the induction principle, the moving element comprising a single vertical shaft to which are attached a number of disks, the whole being supported on jewel bearings. The position of each element relative to the disk is adjustable, and its torque may be varied from zero to maximum, thus providing compensation for differences in instrument transformer ratios. The main control force is provided by two heavy spiral springs of the conventional type. The pen-arm includes a simple straight-line motion, so that the 5-inch scale-width strip-chart has rectangular coördinates. Damping is accomplished by a vane operating in a sealed mercury chamber. Small pilot lights energized from special windings on the electromagnetic systems provide a positive check on the excitation of the voltage windings. These instruments are regularly supplied for combinations of 4 to 14 polyphase circuits, and for telemetering purposes can be fitted with a Selsyn transmitter similar to that shown in Fig. 44-43.

Westinghouse Totalizing Recorder

The Westinghouse totalizing recorder, Fig. 45-4, embodies the Kelvin balance movement described in connection with relay-type recorders.[3] Polyphase units mounted one above another are mechanically linked together with a light metal coupling, so that their joint reactions may be opposed by a common control force. The circuit connections and balancing mechanism are substantially identical with those described in the earlier sections of this work. The calibrated width of the chart paper is 5¼ inches. These instruments are listed for circuit combinations of 2 to 12 polyphase elements.

Baker Totalizer

The Baker totalizer embodies a Kelvin balance type of unit, the control force being provided by the action of gravity on a movable weight. The general principle is similar to that of the Westinghouse "Type G" relay recorder.[3] Instead of a single Kelvin balance, the required number of measuring units are grouped in vertical relationship, the current coils being adjustably mounted on a common base plate and the potential coils carried on a pair of rods passing verti-

[3] *Instruments*, January 1935, page 12.

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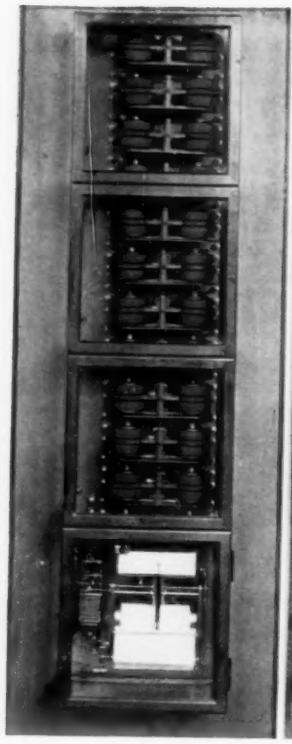

Fig. 45-4

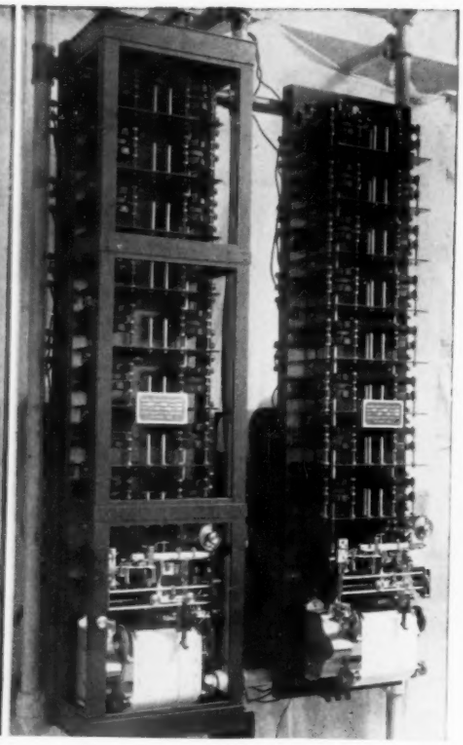

Fig. 45-5

cally through the centers of the two sets of current coils. These rods rest on knife-edge bearings on opposite ends of a common balance arm, and are positioned by frictionless guides at their upper ends. Unbalance of the two ends of the arm, representing the total watts load in the instrument, is opposed by a weight which is automatically positioned along a track attached to the moving element until balance is restored. A pair of Baker totalizers, each having eight polyphase elements (one instrument being connected as a wattmeter and the other as a reactive volt-ampere meter[4]) is shown in Fig. 45-5; and a close-up of the recording and control mechanism in Fig. 45-6.

[4] *Instruments*, July 1934, page 142, Figs. 35-9 and 35-10.

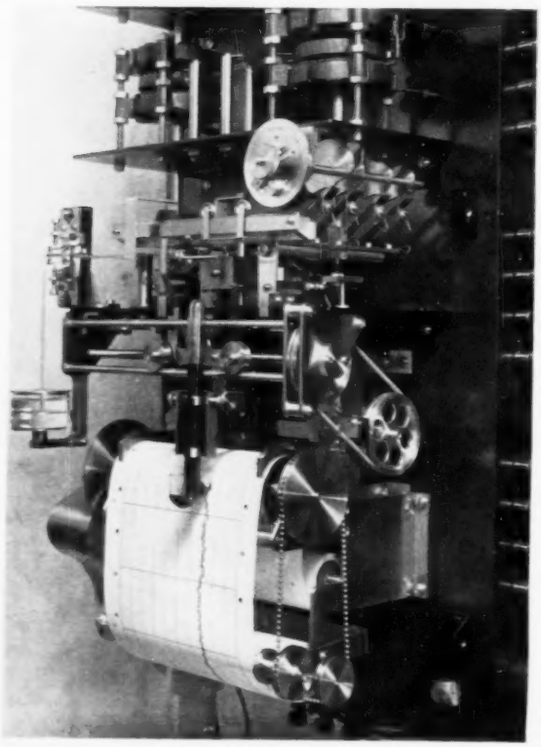

Fig. 45-6

The original instrument of this type, installed in 1914 in the plant of the Ontario Power Co. at Niagara Falls, contains 24 polyphase elements, representing a total power load of 160,000 kw. On the 5¼-inch graduated chart-width the instrument may be given different zero settings providing four 50,000-kw. ranges (0-50,000; 30,000-80,000; 70,000-120,000; 110,000-160,000). Zero suppression is effected by weights hung upon or shifted along the balance-arm by an external manipulator. The 10,000-kw. overlapping of the ranges enables operators to anticipate load variations, and minimizes the frequency with which the zero must be changed.

The most recent Baker totalizers employ an electronic control system. The pen-carriage is driven by a reversible (Barcol) motor with wound pole tips. Rotation of the motor is governed by applying to this winding a voltage derived from an electron tube system subject to contacts on the balance arm. Tests have shown that a resistance of 20,000 ohms in series with the contacts reduces the pen-speed by only 10%.

The original instrument has been checked three times in its service of more than twenty years, the most recent calibration showing the three lower ranges as being within 0.1% of their original value, and the upper range 0.3% in error, which was rectified by correcting the zero-suppressing weight. The original knife-edges have never been out of place; and the above correction represents the only change which has been made in the calibration.

2. Instrument Transformers and Combinations

The general purpose accomplished in the use of instrument transformers for summation purposes is to provide in the current winding of a wattmeter or watthour meter a current which shall represent the resultant of the currents in the several circuits whose power loads are to be added. In order to make use of this principle it is necessary that (1) all the currents must be derived from a common source, or from sources in definite synchronism, and (2) there must be applied to the potential coils of the wattmeter a voltage which can be taken as truly representative of the common voltage under which the several loads operate. Such systems are therefore limited in their application to the totalization of loads derived from a single generator or a group of generators connected to a common bus. These systems may be discussed under two general headings: (a) Multiple-primary current transformer; (b) Current transformers with secondary windings in parallel.

(a) Multiple-primary Current Transformer

The idea of this device is diagrammatically shown in Fig. 45-7. Its secondary winding is suited for connection to the current coils of the wattmeter in the ordinary way, but instead of having a single primary coil it has a group of windings, each usually 5 amperes, designed to be energized from the secondaries of current transformers themselves connected in the power circuits. Thus, where four circuits are to be totalized, each element of the wattmeter or watthour meter would be energized through a current transformer having four 5-

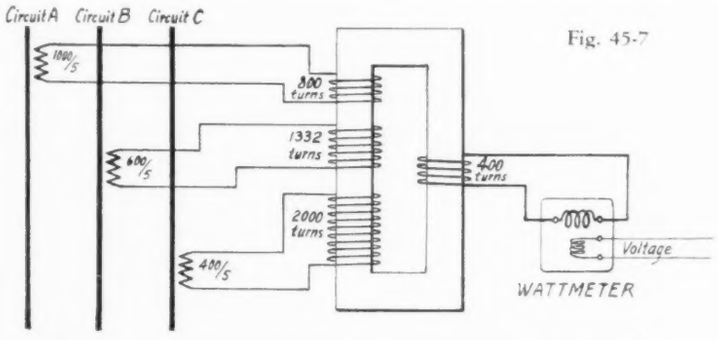

Fig. 45-7

ampere primary windings arranged to combine their magnetic effects on the core, and energized in turn from the current transformers on the four feeders involved in the measurement. The ratio of a totalizing transformer is usually such that 5 amperes flowing in *each* of the primary windings simultaneously would produce in the secondary a current of 5 amperes representative of the resultant—and not the sum—of those in the primary windings. This system makes possible the totalization of the loads on a number of separate feeders by means of a standard polyphase wattmeter or watthour meter, as the case may be, and enables allowance to be made for different transformer ratios on different circuits. Example[5]:

In Fig. 45-7 corresponding conductors are shown for three distinct feeders, the arrangement of course being duplicated for the several phases. It may be assumed that the loads are such as to require current transformers of 1000/5, 600/5 and 400/5 ampere ratings respectively. The totalizing transformer in addition to the usual secondary winding carries three primary windings energized from the secondaries of the transformers on the respective circuits. Since the voltage of the several feeders is

[5]Edecumbe & Ockenden, Industrial Electrical Measuring Instruments, 3rd Edition, Pitman, 1933, pages 499-500.

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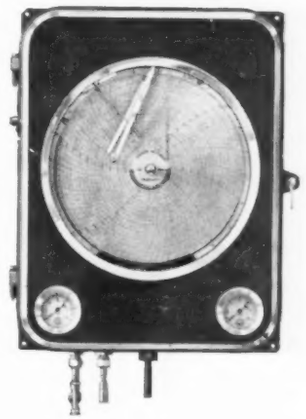

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● Bulletin T-310 describes the Johnson "Record-O-Stat" and H-310 indicates various wet-bulb attachments.

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assumed to be the same for all, it follows that the current flowing in the secondary of the totalizing transformer must be the same for a given current flowing in any one of the metered feeders. That is, the over-all transformation ratio must be the same from any one of the lines to the totalizing transformer secondary. A convenient over-all ratio in this case would be $(1{,}000 + 600 + 400)/5, = 2{,}000/5$. Selecting 400 turns for the secondary winding, the number of turns in each of the three primaries would be as follows:

$$\text{for circuit A } \frac{2000/5}{1000/5} \times 400 = 800 \text{ turns}$$

$$\text{for circuit B } \frac{2000/5}{600/5} \times 400 = 1332 \text{ turns}$$

$$\text{for circuit C } \frac{2000/5}{400/5} \times 400 = 2000 \text{ turns}$$

The use of the multiple-primary current transformer for totalizing finds particular favor in large utilities where considerable accuracy is required and where shop facilities are available for constructing special transformers to individual requirements.

(b) Current Transformers with Secondary Windings in Parallel

In order to totalize the loads in a number of feeders by connecting current transformer secondaries in parallel, it is necessary that these transformers be identical in ratio, and preferably in design. The connections would be similar to those indicated in the single-line diagram of Fig. 45-8. Here it is apparent that the current coils of the meter must have a carrying capacity equivalent to the sum of the secondary currents. Thus, with four circuits having their

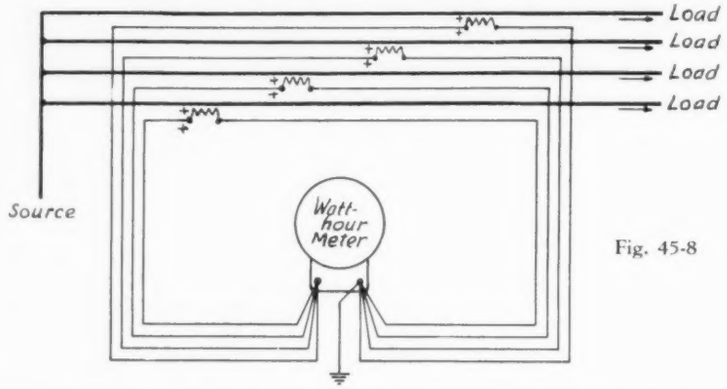


Fig. 45-8

respective currents determined with standard types of current transformers, having 5-ampere secondaries, the wattmeter would have to have a 20-ampere current coil at whose terminals the four secondary circuits would be connected in parallel. The latter requirement may be obviated by interposing between the secondary windings of the line transformers and the current coil of the instrument a current transformer having a ratio of $5N/5$ amperes, where N represents the number of circuits included in the summation. This simplifies the construction of the instrument, but somewhat decreases the inherent accuracy of the system.

It has already been pointed out that totalizing systems in which current transformer secondaries are interconnected are limited in their application to loads originating in a common source. There are also several inherent sources of error which must be taken into consideration where high accuracy is required. For a full discussion of these, see the references.[6-8]

In general it may be said that since in any of these systems each current transformer may be considered as a highly inductive shunt across the secondary terminals of the others, it becomes desirable to maintain the common secondary burden at a low value. The accuracy of the systems also decreases with unequal loading on the respective feeders.

It will be noted that this system of totalizing requires only the combining of outputs of *current* transformers, and that a single source of voltage representative of that of the system is employed, it being necessary only that there be assured a voltage supply to the metering system as long as any one of the metered circuits is alive. This sometimes makes it necessary to have several alternative sources available, the proper source being selected by means of suitable transfer switches. Care must be taken to avoid any arrangement which might parallel the secondaries of two voltage transformers, as a supposedly dead line might thus become energized, introducing an extremely hazardous condition.

[6]Serial Report of the Meter Committee of N. E. L. A., 1927-28, Pub. No. 278-43.
[7]Commercial A-c. Measurements, G. W. Stubbings (Van Nostrand, 1930), pages 124-131.
[8](For effect on associated protective apparatus) Relay Systems, Monseth & Robinson (McGraw Hill, 1935), page 269.

NEW INSTRUMENTS

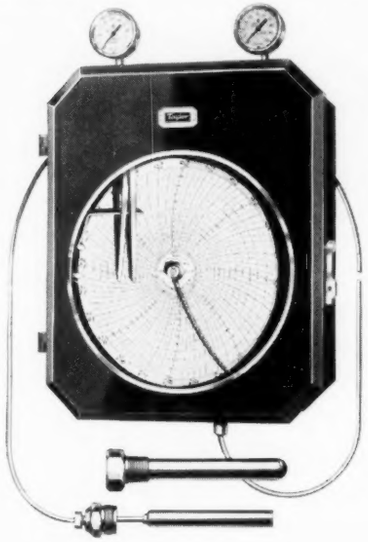
In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

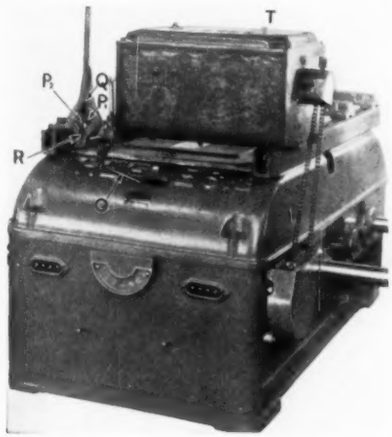
Low-lag Separable-well Tube Systems

New "Thermospeed" separable-well tube system is said to have a speed response closely approaching that of manufacturer's fastest bare-bulb tube systems: approx. six times faster than average separable-well tube system now in service; almost twice as fast as separable-well thermocouples. Manufacturer looks upon "Thermospeed" construction as most important advancement in tube-system design in recent years.—*Taylor Instrument Companies, Rochester, N. Y.*



Hydraulic Command for Variable-speed Drives

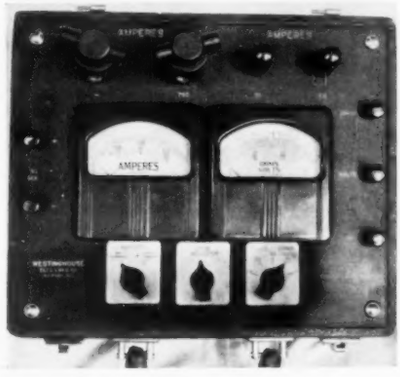
Applicable to maker's variable-speed transmissions of sizes "000" to "8" inclusive, whether new or now in use, this hydraulic unit makes possible continuous automatic control of speed within the limits of the transmission. It is actuated by an indicating lever attached by cable, link, etc., to any element whose displacement is a function of the speed to be controlled. The force required being of the order of 2 or 3 oz. and the minimum displacement required to bring about a change of speed being "a very small fraction of an inch," such available elements as floating rolls, diaphragms (where pressure is a function of speed), floats (where level is a function of speed), etc., can be utilized to actuate the lever. Tension springs P_1 and P_2 protect control mechanism in event of sudden or excessive motion of primary element. The "Hydraumatic Control" comprises a fractional-h.p. a-c. or d-c. motor continuously driving a geared pump which delivers a steady stream of oil to the pilot arrangement. This consists of (1) a relief valve through which



the oil passes when the speed is correct, and (2) a two-way valve which is the actual pilot. The power device proper is a reversible hydraulic motor; it is connected to the shifting screw of the variable-speed transmission by sprocket and chain. Normal time for shifting from one extreme to the other is 35 seconds; mode of control is non-hunting.—*Reeves Pulley Co., Columbus, Ind.*

D-c. Industrial Analyzer

Minimizing both set-up and testing time, this compact new analyzer is self-contained in a case 8" x 11" x 13". It has two instruments. The ammeter has self-contained shunts for 7½, 75, 750 amps. and can also be changed to a 50 millivolt instrument by changing the position of the switch. This permits the use of any range, 50 millivolt external shunt. The second instrument reads volts and ohms, and there is a switch for changing ranges (150, 300 and 750 volts; ohm ranges are 5 and 500 at center of scale, can be read from 0.1 ohm to 20,000 ohms). The two instruments permit the reading of amperes and volts at the same time. Thus the set can be used in making practically any type d-c. voltage, current or resistance test with minimal connections.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*



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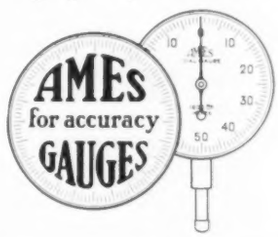

Fewer parts, sturdily constructed and easily replaced, make gauges that measure accurately for long periods of time. In AMES Gauges simplification is accomplished by assembling wheels, pinions and springs onto one large staff that otherwise would require two or more staffs. This exclusive and patented single staff assembly has only a simple support, held by but two screws.

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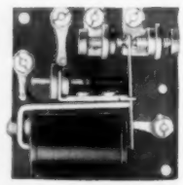
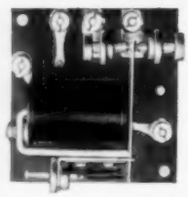

2C


1C

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14 Milliwatts for positive operation.

ADJUSTABLE
Pull up—drop out—speed.

DROP OUT
From 50 to 85% of pull.

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Fine silver—1½ amps 110 V. A.C.

RANGE
.0005 V. 25 amps -to- 20 V. .00065 amps.

FEATURES
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2C—Speed .001 seconds.

RUGGED
Some customers report 4 years continuous satisfactory operation.

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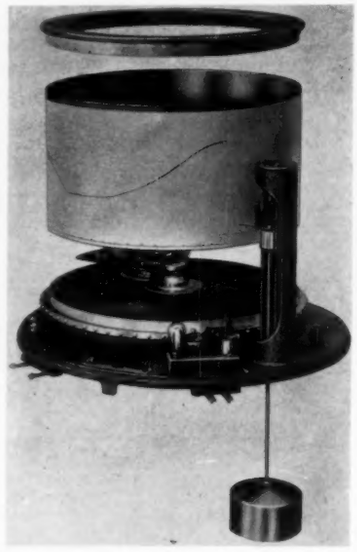
Water Level Recorder for Hydraulic Laboratories

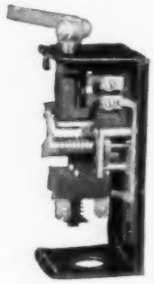
For the solution of problems connected with reservoirs, spillways, rivers, and particularly estuaries where complex tidal effects are involved, new "Stevens Type M Recorder" consists essentially of a chart drum driven by an electric clock, and a capillary pen supported on a 3" copper float. Chart is 36" long, and



time scales of 36, 18, 12, 6, 3, and 1½ in./hr. may be had, all interchangeable in the same instrument. Gage scale is 1:1, that is, the graph is actual size. The range of water levels is normally 0.5 ft.; greater ranges to order. Pen is said to be sensitive enough to register changes in levels of 0.001 ft. Wherever a number of recorders are in use (as on the same model) they may be provided with time markers all operated by a master recorder, so that a jog in the time line of each recorder is made, say, every minute. There is also available a push-button device whereby a mark is made simultaneously on all recorders.—*Leupold, Volpel & Co., 425 N. E. 70th Ave., Portland, Oregon.*

Shipper-rod-operated Master Switch

A new shipper-rod-operated master switch, which performs the function of a two-button momentary-contact push-button station, is said to possess advantages



over previous switches of this type in that its magnetic contactor will pick-up and seal-in even when the shipper rod is operated rapidly, and will drop out and remain unenergized—in the case of voltage failure—even when the shipper rod does not complete its travel. A short time delay between making and breaking the pick-up circuit is employed, so that this circuit will always be broken after it has once been established, regardless of the position in which the shipper rod is left.—*General Electric Co., Schenectady, N. Y.*

Oxygen Regulator

Primarily designed to deliver large volumes of oxygen (>1000 ft.³/hr.) at relatively high pressures such as on heavy cutting, deseaming, furnace tapping, etc., new heavy-duty "Airco-DB style 8490" finds use principally where oxygen demand is greater than can be handled by the conventional regulator, where close pressure regulation and a low end-point are desired, or where precise pressure regulation with medium flows is involved. It is of the two-stage pressure reduction type. Maximum operating pressure 200 lbs./in.²; maximum delivery capacity 3000 ft.³/hr. provided delivery pressure >100 lbs./in.²; pressure regulation is practically independent of rate of flow from full-cylinder pressure down to regulation end-point; pressure variation will generally be $<\pm 0.5$ lb./in.². Departing from convential regulator design, this regulator uses the Airco laboratory-developed "feed-back" principle. (See full description thereof, *Instruments*, Sept. 1933, pages 167-170.) Difference between first- and second-stage pressures is always maintained substantially equal to first-stage pressure when adjusting screw is entirely released.—*Air Reduction Sales Co., Lincoln Bldg., 42nd St., New York City.*

Static A-c. Voltage Regulator

Obviating need of frequent inspection, adjustment and maintenance, a voltage regulator without contacts, tubes or moving parts exemplifies the increasing trend

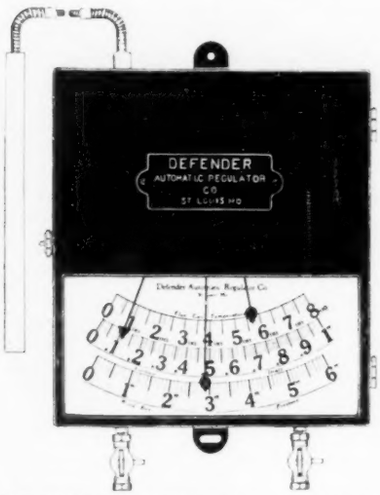
towards simplification of voltage regulating equipment. Rectified a-c. current proportional to the load is used to compound the exciter field, varying with the load on the generator. Energy for required additional voltage-corrective effect is obtained from generator potential and through a combination of reactor, resistor and dry type rectifier circuits. Designed for small a-c. units, the new device in its initial size is applicable to units where exciter field current <1 amp. —*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Microchemical Microscope

Newest product of the Reichert Optical Works (Austria). Rack and pinion coarse adjustment. Square object stage with sliding sleeve, for a condenser or a polarizer. Plane and concave mirror, adjustable in all directions, may be swung aside for obtaining oblique illumination. Objectives 4½ x, Eyepiece 8 x; magnifications 36-80 x. Optional, double nosepiece for objectives. Accessories: (1) *for measuring*—Eyepiece micrometer 6 x, stage micrometer 2 mm. divided into 200 parts. (2) *spare optics* — Achromat-objective 16 x, eyepiece 10 x, two-lens Abbe condenser ap. 1.20 with iris-diaphragm; detachable front lens, rear lens may be used separately; same condenser may be furnished with vertical adjustment by spiral movement. (3) *for polarized light*—Centering rotating stage inset with circular division, 360°, and index, for placing on the object stage of the microscope; also polarizers and analyzers for both high- and low-power magnifications—*Pfaltz & Bauer, Inc., 300 Pearl St., New York City.*

Draft Gages

To maker's line of boiler-house instruments is added a line of indicating and recording draft gages employing new "suspended type" slack-leather diaphragm pressure-measuring units of an improved design which facilitates both zero setting and calibration: an adjustable pendulum obviates the need of tools. Indicators and recorders are of square form, with one, two or three scales. Indicator cases are 10"x10"x4½"; recorder cases are 12¼" square by only 3" deep, chart diameter 10". In addition to pressure-measuring elements, there are available for indicators or recorders flue-gas thermometric elements of nitrogen-filled type with remote bulbs as illustrated.—*Defender Automatic Regulator Co., St. Louis, Mo.*

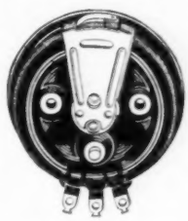


Positive-action Positioner for Control Valves

Developed to eliminate sticking of air-operated control valves, the "Vernier Valvactor" enables throttling type air-operated control instruments to make small gradual adjustments of the control valve position regardless of friction or hysteresis. It is claimed that the air from the control instrument need change as little as ½" of water to cause a corrective positioning of the valve and force the stem to take a position within 0.001" of the previous one. In the great majority of installations the maker's control valves will respond proportionately to small changes in air pressure without this device. It assures exact valve response where the valve stem packing must be very tight to prevent leakage; where the fluids are viscous or contain solids and friction is otherwise unavoidable or wherever there is danger of valve friction developing. The unit is mounted in a cast aluminum case, is completely weatherproof, and may be exposed to the elements. The case is also available in gas-tight construction properly vented for operation indoors on gas supply with the vent piped to a safe spilling point. The positioner can be attached directly to the spring housing of all sizes of "Stabilflo" valves. —*The Foxboro Co., 46 Neponset Avenue, Foxboro, Mass.*

Power Rheostats

Recommended for such applications as small-motor speed control, temperature control of vacuum-tube filaments or small heating devices, voltage or current regulation in laboratory and shop, new rheostats added to maker's line are of vitreous enameled construction with wire-wound elements and "special metal graphite composition" contact shoes. They are arranged for single-hole mounting. Shaft and bushing are insulated from contact arm, permitting mounting on metal panels. Four sizes are announced, in 25-, 50-, 100- and 150-watt ratings.—*Electrad, Inc., 173 Varick St., New York City.*



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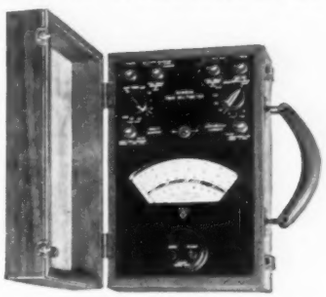

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Grid Glow Tube with Built-in Time Delay

Among advances in gaseous discharge tube design embodied in new "KU-676" tube are a built-in time delay for protection of the cathode when starting the

Fig. 1

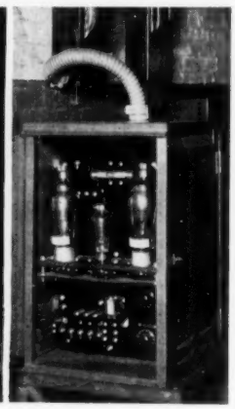
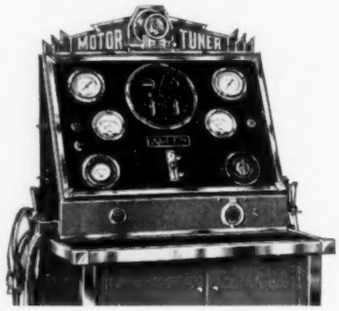


Fig. 2

tube, and a new cathode design resulting in a high ratio of crest to average current rating which is important for such applications as Ignitron control, welding timers, 6-phase rectification, etc. Directly-heated portion of cathode is an edge-wound helix closely surrounded by an indirectly-heated portion of perforated metal coated only on the inside surface. Discharge is thus forced to pass through perforations in screen and then outward through annular space between screen and first radiation shield. Purpose is electro-static shielding of active surfaces of cathode to such an extent that they are not subject to high field strengths and are also protected from excessive positive ion bombardment. Fig. 1 shows the new tube; Fig. 2 shows two of them in a spot welding timer. Current rating of "KU-676" tube is 6.4 amps. average and 75 amps. crest while cathode heating energy required is 55 watts.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Motor Tuner

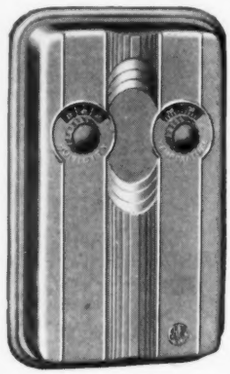
With new "Model E-166" makers assert that electrical tests can be made on the battery, starter, generator, voltage regulator, relay, ammeter, ignition cables,



coil, condenser, spark plugs, wiring and radio resistors. Also, through use of compression and vacuum gage, it tests valves, fuel pump, rings, and other mechanical units. Supplied with the "E-166" are a Delco-Remy test coil, and coil specifications for Delco-Remy and Autolite products.—*Allen Electric & Equipment Co., Kalamazoo, Mich.*

Combined Humidistat and Thermostat

Two new instruments for air-conditioning applications are announced, both housed in a new smaller and modernized case (7" x 4½" x 1¾") but differing in their functions. One is a new model of the "Comfortrol" described fully in our May 1934 issue, page 101; the other is a new combination, the "Hytherstat," which likewise combines a humidistat and a thermostat but without intergeared setting dials. It consists of one case



enclosing two independent instruments mechanisms: a humidistat and a thermostat. Each of these, as described in *Instruments*, Feb. 1933, page 39; May 1933, pages 105, 109; May 1934, page 98; is available in numerous styles, such as snap-action single-pole double-throw for humidifier control; for heater control, etc., so that a considerable variety of combinations is possible—*Julien P. Friez & Sons, Inc., Baltimore, Md.*

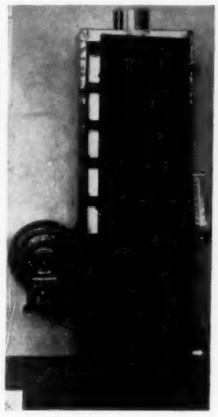
Pressure Switches

Announcement of new "Klixon Type PS" makes available for pressure control of steam-heating boilers and various industrial applications a snap-acting device which is adjustable both as to cut-in setting and differential. Eight 2-wire and 3-wire models are announced, for electrical ratings from 0.3 amp. to 10 amp. ¼ h.p. operation: Motion resulting from pressure exerted on bellows is transmitted directly to the "Klixon" disk actu-

ating the contacts with a positive snap-action. Bellows, disk, and contacts are enclosed and protected by bottom case. Klixon disk obviates need of toggle mechanisms and minimizes points of wear and lost motion. Adjustments for both cut-in and differential pressure settings are independent. Both are enclosed to prevent accidental change or tampering, and are accessible by removing the cover which is held by two screws. Terminals are provided with insulating caps, leaving no exposed current carrying parts.—*Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.*

Pulp Drying Oven

Quick drying and low-cost operation are claimed for this gas-heated unit, as well as ease of regulation. Casing dimensions are 60"x19"x19"; five baskets, each measuring 16" square by 4" deep, have perforated bottoms and each will accommodate <5 kg. of pulp. Gas consumption is approx. 28 ft.³/hr. and blower is driven by a ⅛ h.p. motor. Air used for drying pulp is heated indirectly by a gas unit specially constructed so that gas fumes will not come in contact with pulp. Heated air is passed through the oven under a forced draft which cuts considerably the time required to dry the pulp: normal grades of pulp containing <20% moisture may be dried in about four hours, it is said, and it requires from five to ten minutes to bring oven to proper drying temperature.—*United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J.*



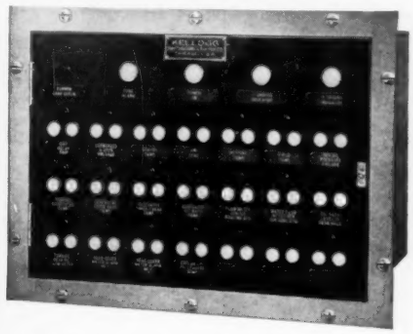
Resonance Indicator

Making use of the "6E5" electron-eye tube, new "Taco" device indicates degree of resonance for accurate tuning of set or individual r.f. and i.f. circuits; is a means of aligning stages; may be used as output meter; checks for "opens" or "shorts" in component parts and circuits; permits of matching condensers and indicates capacity values; checks audio fidelity; may be used as a bridge indicator in place of galvanometer. Employs two "6H6" metal tubes: one is used in voltage-doubling circuit to supply necessary plate power for "6E5;"

other operates as linear diode detector, the rectified signal of which is amplified by triode section of "6E5" and applied to control element of latter's electron-ray section. One "6H6" and the "6E5" are housed in metal case measuring 4½" x 5⅜" x 5⅜"; second "6H6" mounts on external metal case provided with test leads and clip. Cord with rubber plug for 110-volt supply. Luminous disk with variable dark segment, provided by electron-eye tube, is seen through recessed shadow-box opening in upper part of engraved face plate. Below is knob controlling sensitivity.—*Technical Appliance Corp., 17 E. 16 St., New York City.*

Annunciator Systems

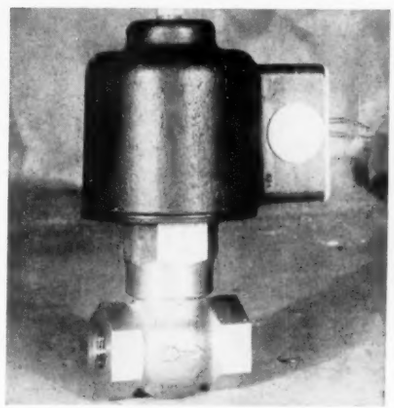
Centralized indication of abnormal conditions such as temperatures, pressures, speeds, flows, illuminations, voltages, currents, etc., is the main purpose



of a new line of signaling units, but improvements reported include also automatic counters registering number of times any light is flashed, audible signals which sound continuously or intermittently and are silenced manually or automatically, etc. Provisions for operation on either continuous or momentary alarm contacts are obtainable with manual, automatic, or remote lamp-reset features. Audible alarms of any size or voltage may be had with any of the reset features. Alarm fusing, ground indication, and instantaneous lamp check are said to make it practically impossible for any part of a plant to fail without giving immediate warning. Each circuit has its name plate. In addition to conventional-form panels as illustrated, makers have brought out also turret-form panels.—*Kellogg Switchboard & Supply Co., 1066 W. Adams St., Chicago, Ill.*

Solenoid Valves

To maker's line of solenoid values has been added a packless type for air, gas, fuel oil (Nos. 1, 2 and 3), water, methyl chloride, "Freon," etc., at temperatures <212°F. New construction permits disassembling without removing from pipe. Bodies are all bronze, screwed, with self aligning bronze needle type disks closing in direction of flow. Removable bonnet carrying solenoid has a single gasketed joint said to be of improved design ob-



viating danger of leakage when used with refrigerant. Three port sizes, two pipe sizes (¾" and ½") and various electrical specifications provide a wide choice. — *Automatic Switch Co., 154 Grand St., New York City.*

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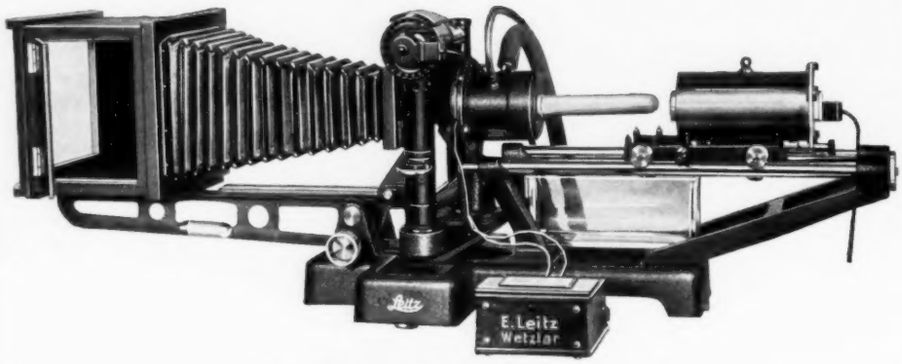

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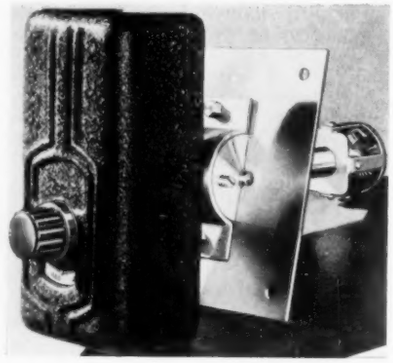
Thermostat for Bonnet, Fan, and Duct Control

Making available a voltage range up to 250 volts, this new thermostatic control for bonnet, fan, and duct service has an adjustable range and an adjustable differential, and its mounting bracket is swiveled for convenience in mounting with the thermosensitive element in the plenum chamber of the furnace. It may be used either as a high-limit control or as a fan switch to permit the fan to operate only when heat is available.—*Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.*

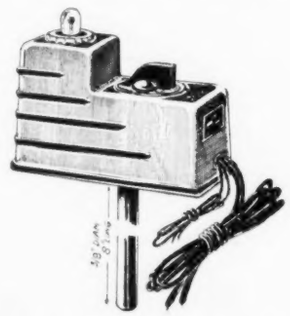


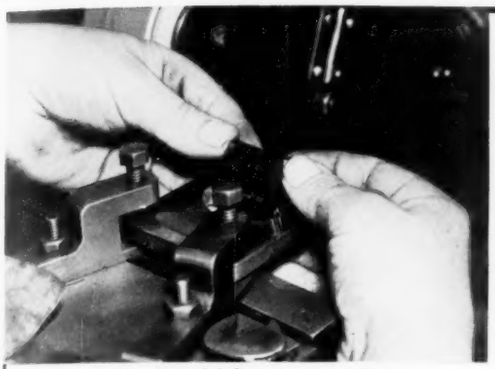
Portable Audio Oscillator

New "Model 79" portable beat-note audio oscillator is continuously variable from zero to 10,000 cycles. From 50 to 10,000 cycles, output voltage is said to be uniform within 2 db and to contain <5% distortion. An output potential of 27 volts is developed at 5,000 ohms impedance. Two type '76 heterodyne r-f oscillators generate the audio voltage which is demodulated in type '76 tube and amplified by an additional audio stage employing a type '76 tube. "Model 79" is operated directly from a 110-volt 60-cycle power line. A built-in vacuum-tube voltmeter serves as a zero-beat indicator and output level indicator when voltage is to be held to limits closer than 2 db.—*Clough-Brengle Co., 1134 W. Austin Ave., Chicago, Ill.*

"Pencil Type" Thermostat

Bi-metallic thermal element consists of invar rod in ⅜" o.d. brass (or other metal) tube; operates lever which actuates contactors in aluminum housing provided with arbitrarily-calibrated setting dial. Feature is a neon pilot light from which separate asbestos-covered wires are brought out for connection to heater terminals. External capacitor is supplied (must be mounted in a cool location). Temperature range (regular) is 500°F.; differential is said to be 1°F. Ratings: 2000 watts 110- or 220-volt a.c.; 900 watts 110- or 220-volt d.c. Designed not only for immersion of rod but for applications where rod is to fit into groove or hole in metal plate, as on presses, etc.—*George Ulanet Co., 85 Columbia St., Newark, N. J.*





Using combination of Johansson Gage Blocks to measure snap gage on a grinder.

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There's one sure way to obtain the greatest degree of precision in any kind of toolroom work. That's to provide the toolmaker with Johansson Gage Blocks — the world's standard of measurement. Complete sets or individual blocks available at moderate prices. ***Write for Catalog No. 11.***

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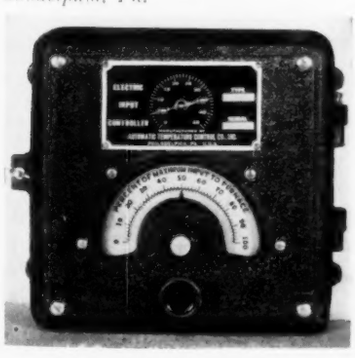
Current-input Controller for Electrically-heated Equipment

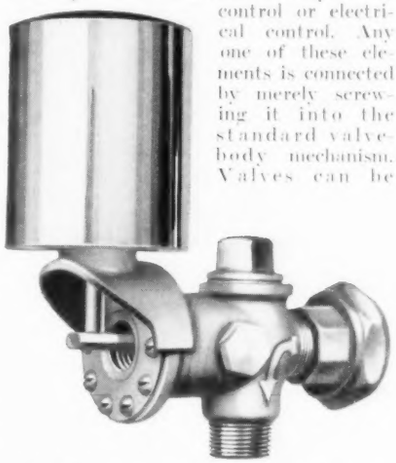
New temperature controller is said to be more flexible in adjustment and more accurate in setting. It is applicable not only to replacement of rheostat control but in combination with existing automatic control. Four standard models: "Model M" designed to prevent a constant load from rising in temperature beyond desired adjustable setting. "Model MT" exercises the same control of overshooting as Model M but, in addition, is provided with built-in time control which brings input-control into action after an adjustable period. Models "F" and "FL" are designed for control where loads are variable. Both models adjust automatically to changes in demand, with Model F serving installations having but slight lag in furnace response and Model FL serving where lag is greater.

(1) *Continuous Furnaces*: Where furnace load is *constant*, Model M is wired in series with low pyrometer contact. For *variable* load, Model F or FL, so wired that rate of current input is automatically decreased or increased by high and low contacts of actuating pyrometer. (2) *Batch Furnaces*: New controllers are said to provide improved temperature regulation in the heating-up period, in the soaking stage, or in both, as required. (3) *Program Control for Batch Heating*: New controller, with maker's standardized time-cam devices, makes possible the control of a complete heating program in which desired heating conditions are governed both as to temperature and time. (4) *Rheostat Replacement for Laboratory Furnace*: New controller is said to afford far greater accuracy of setting than obtainable with a rheostat. Controller uses current only in proportion to a given setting.—*Automatic Temperature Control Co., 34 East Logan St., Philadelphia, Pa.*



Control Valves

A new line of control or automatic shut-off valves is announced, with interchangeable elements for air control, steam-pressure control, water-pressure control or electrical control. Any one of these elements is connected by merely screwing it into the standard valve-body mechanism. Valves can be



adapted to automatic operation, to remote control, or to automatic operation plus an interlock with a manual-reset device. The valve itself has but two moving parts and is held firmly in position, when closed, by a cadmium-plated spring. Needle and seat are of stainless steel; all other parts are also of "non-corrosive metals." Any part of the valve can be removed in a few seconds, it is said, without detaching the valve from the line. To minimize resistance and avoid sticking, a packless gland in the form of a brass bellows is used. The interlock and manual-reset device is a latch-and-weight arrangement which holds the valve in position after it has closed, until the weight has been reset manually. The air-control mechanism is of the piston type, and a pressure of 3 to 50 lbs./in.^{2} may be used. In the steam or hydraulic control, the pressure operates through a bellows, preventing leakage or blow-by. The steam-oil and air-oil interlocks are used on industrial oil burners where the atomizing agent, either steam or air, and the oil are supplied by separate units. The electrical control is in the form of an electromagnet, and the spring which closes the valve is separated from the fluid. The electrically-operated valve is used for remote control of oil, water, brine, etc. It is said that with any type of control mentioned, these valves "will handle the most viscous oil without sticking."—*Lammert & Mann Co., 288 N. Wood St., Chicago, Ill.*

MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

1025 **Shielded Capacitance and Conductance Bridge.** Leaflet T-337a illustrates this instrument for capacitance, S. I. C. and power factor of dielectrics up to 50 kc. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

1026 **Postalett.** A 4-page folder illustrates this device which has the shape of a fountain pen. It was originally built for use in weighing mail, but should find extensive application by development and research engineers for measuring forces up to 8 oz. Exact Weight Scale Co., Columbus, Ohio.

1027 **Chlorofeeder.** Bulletin COF-M illustrates the application of this automatic feeder for sterilizing water. Proportioneers, Inc., Providence, R. I.

1028 **Optical Instruments.** Catalog L-2 covers the following: Spectrometers, Spectroscopes, Spectrographs, Polariscopes, Interferometers, and Light Sources. Gaertner Scientific Corp., 1211 Wrightwood Ave., Chicago, Ill.

1029 **Apparatus for Testing Petroleum Products.** Catalog 160, 80 pages, contains detailed specifications and references to governing standards. An A.S.T.M. reference index is included, indicating at a glance the apparatus necessary for each A.S.T.M. designation. Precision Scientific Co., 1749 N. Springfield Ave., Chicago, Ill.

1030 **Spectrometric Equipment.** Catalog D-221, 32 pages, covers the basic theory and design, direct vision spectroscopes, Bunsen spectroscope, laboratory wavelength spectrometer, large spectrometer, universal spectrophotometric equipment, quartz ultra-violet monochromator. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

1031 **Effective Temperature.** Julius H. Friez & Sons, Inc., Baltimore, Md. have issued a sheet entitled "Comfort—Effective Temperature—Concerns Us All" which makes no direct reference to Friez products.

1032 **Micro-Projectors.** Catalog E-20, 16 pages, describes and illustrates several projectors. Prices are given. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

1033 **Condenser and Resistor Catalogue.** The 1935 Aerovox catalogue covers the entire line of electrolytic paper, mica and other condensers, as well as several types of resistors. Aerovox Corp., 70 Washington St., Brooklyn, N. Y.

1034 **General Radio Experimenter.** The November issue has the following articles: Waveform Errors in the Measurement of Power Transformer Losses; The Edgerton Stroboscope; Type 559-B Noise Meter; Uses of the Variac; and Relay-Rack Mounting for the Electron

Oscillograph. The December issue: The New Modulation Monitors; A Note on Measurement of Meter Speeds; and A Direct - Indicating Audio - Frequency Meter. The January issue: A New Precision Condenser; and High Speed Motion Pictures. General Radio Co., 30 State St., Cambridge A, Mass.

D35 **Microscopes.** Catalogue M-70. 16 pages illustrates and describes various microscopes. Prices are also included. The following instruments are also included: Rotary microtome, magnifiers, delineascopes and projectors. Spencer Lens Co., 19 Doat St., Buffalo, N. Y.

D36 **Clip-on Ammeter.** 4-page bulletin lists the 23 important features of the new clip-on ammeter. Ferranti Electric, Inc., 130 West 42 St., New York, N. Y.

D37 **Laboratory Microscopes.** Catalogue D-195, 8 pages, covers the Type H microscopes. A table gives magnifications and real fields, while another gives prices. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

D38 **Microscope Illuminators.** Catalogue D-119, 20 pages, illustrates and describes microscope lamps. Prices are included. Bausch & Lomb Optical Company, 615 St. Paul St., Rochester, N. Y.

D39 **Hytherstats and Comfortrols.** Bulletin C, 4 pages, describes a joint control of humidity and temperature and effective temperature control. Julien P. Friez & Sons, Inc., Baltimore, Md.

D40 **Relative Humidity and Temperature Indicator.** Bulletin D, 2 pages, covers the relative humidity and temperature indicator. Julien P. Friez & Sons, Inc., Baltimore, Md.

D41 **Air Meters.** Bulletin F gives a brief description as well as an illustration of Friez Air Meters. Information for operation and useful conversion tables are included. Julien P. Friez & Sons, Inc., Baltimore, Md.

D42 **Hydrometers.** A 4-page folder of the Permutit Company, 330 West 42 St., New York, describes the Pacometer which is a new, automatic, compensating hydrometer for the control of boiler salines and other applications.

D43 **Viscosimeter.** A 6-page folder of the Fish-Schurman Corp., 230 East 45 St., New York, describes the Hoeppler Viscosimeter which determines the viscosity by means of a falling ball. The viscosity is given directly in centipoises and the instrument has a range of .01 to 1,000,000 centipoises with an accuracy of .1% to .5%.

D44 **Dilatometer.** A 40-page bulletin describing the Leitz Automatic Recording Dilatometer for the thermal analysis of metals. The principle of operation is described in considerable detail and the instruments are illustrated. E. Leitz, Inc., 60 East 10 St., New York.

D45 **Hythergraphs.** A 4-page bulletin H, describes an instrument for recording the relative humidity and dry bulb temperature. Julien P. Friez & Sons, Inc., Baltimore, Md.

D46 **Contact Pyrometer.** Bulletin 986 illustrates the measurement of bearing temperatures with the Alnor Pyro Point Contact Pyrometer. Illinois Testing Lab., Inc., 142 W. Austin Ave., Chicago, Ill.

D47 **Combustion Control.** Bulletin 2246, 12 pages, describes the instruments and combustion control of three companies, the Hays Corp., the Carrick Engineering Co. and the Cochrane Corp., who have cooperated to place at the disposal of industrial users a system of measuring and control equipment for boiler operation. Hays Corp., Michigan City, Ind.

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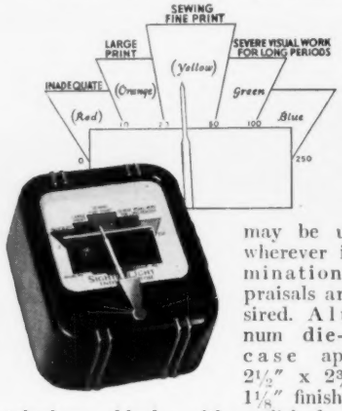
Comparator Microscope

For use by tool makers for accurately measuring extremely small points on tools, dies and finished products and for use in inspection departments for checking purchased articles against required specifications, a new comparator microscope consists of a 60-power microscope with an adjustable eyepiece for focusing sharply on

the cross-lines on the microscope field and a movable carriage on which the objects are fastened. The carriage has a movement of 5" longitudinally and 1" laterally. Proper means of illumination are incorporated in the design so that measurements can be made on opaque objects. Measurements in one direction are read to 0.001" directly on a 2" diam. micrometer dial, and in the other direction to 0.01" from a vernier scale. Frame assembly and carriages are constructed of aluminum alloy; all other moving parts of non-corrosive metals.—*Stupakoff Laboratories, 6625 Hamilton Ave., Pittsburgh, Pa.*

Pocket Illuminometer

Small enough to be conveniently tucked into vest pocket or woman's purse, a new light-prescribing and measuring device, called the "Sight Light Indicator,"



may be used wherever illumination appraisals are desired. Aluminum die-cast case approx. 2½" x 2¾" x 1⅛" finished in telephone black with polished trim. Weight 7 oz. The scale covers 0-250 foot-candles, is logarithmic rather than linear so that low intensities are measurable, bears printed notations recommending minima for different types of work, and is also divided into colored zones (from red for danger to blue for safety). Weston "Photronic" dry-disk self-generating photocell is located in recess on face of instrument, so that user, in reading the scale, naturally assumes his normal working position (in which his head and shoulders may intercept much of the incident light) and the instrument then shows whether changes should be made in location of light fixtures, etc.—*The Sight Light Corp., 342 Madison Ave., New York City.*

Thermal-induction Relay

Designed for use in oil-immersed motor controllers, a new thermal-induction relay with tripping characteristics facilitating starting high-inertia loads at full voltage, has a series line-current coil which produces a flux in a magnetic core and induces a current in a copper sleeve

about this core. Heat from this copper sleeve is directly conducted and radiated to a bi-metal strip whose deflection causes a set of contacts either to open or to close. The contacts, normally closed, have a slow-opening action, preventing too quick tripping on overloads. In tripping at any load, localized temperatures are said to be much lower than with the heater-type relays heretofore used in oil: no more carbonization and consequent changes in relay characteristic.—*General Electric Co., Schenectady, N. Y.*

Transformer Speed Regulators for Capacitor Motors

Manually operated transformer speed regulators for high- and low-torque capacitor motors, with and without full-voltage starting for single-phase and polyphase fan motors, consist each of a tapped autotransformer and a snap switch, and, for providing full-voltage starting, a relay which affords automatic transfer to the desired running position. With special additions, these new regulators are available for reversing service as well as for operation from external sources such as thermostats in an air-conditioning system.

Snap switch provides for three speed positions, and other low speeds may be obtained from the autotransformer through reconnection of transformer taps to snap switch, giving a total of seven reduced speeds. The regulators are for single-phase motors, rated <2 h.p. and for polyphase motors rated <5 h.p. The polyphase regulator combines two autotransformers connected in open delta, with a rotating snap switch mounted on a sleeve between the transformer cores. *General Electric Co., Schenectady, N. Y.*